



Partial Depth Repairs in Concrete Pavement

Gordon “Gordy” Bruhn

Concrete Pavement Rehab Website

Pavement rehabilitation program

Investigation

It is recommended that investigation into soundness of the pavement be performed before a project and specific repairs are decided upon. This investigation should include 'chaining' the pavement, coring and sometimes milling at the joints to determine severity of deterioration, and coring near and far away from the joints to test for freeze-thaw durability.

Some Joint Are Too Far Gone
This Pvmnt has Material Issues...
Possible Low Entrained Air Content



Freeze Thaw Expansive Aggregate... aka D-Cracking



D-cracked pavement

Petrography Found Alkali Silica Reactive Aggregates



Coring the Project is **ESSENTIAL**.

Partial Depth Repairs work when placed on solid concrete.

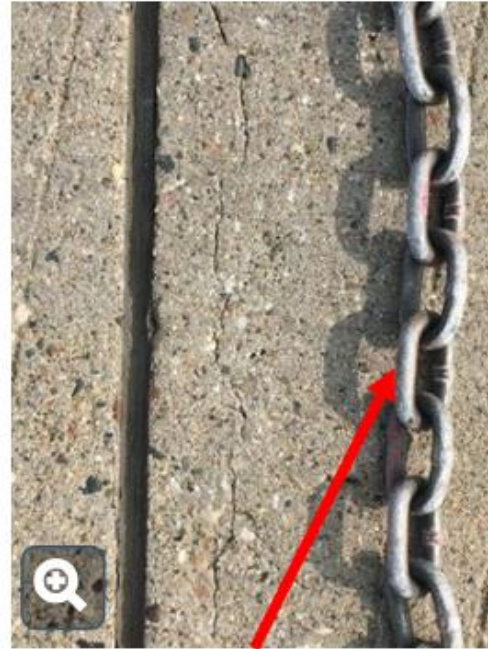


When in Doubt, Take it Out!



Rock Pick (aka "Chipping Hammer")

- Steel head and handle forged as one piece
- Square face and pointed tip
- Hammer weight: 14 ounces or 22 ounces
- Pointed tip is useful when checking partial depth repairs
- Hammers with wooden handles seem to distort the sound of the concrete



Chain

- Recommended chain link diameter: 1/4 inch or larger
- Recommended chain length: Approximately 5 feet (adjust for your height)
- Larger diameter chain doesn't seem enhance the sound



Spray can with extension handle (aka "Paint stick") for marking

Concrete Unit Recommendations

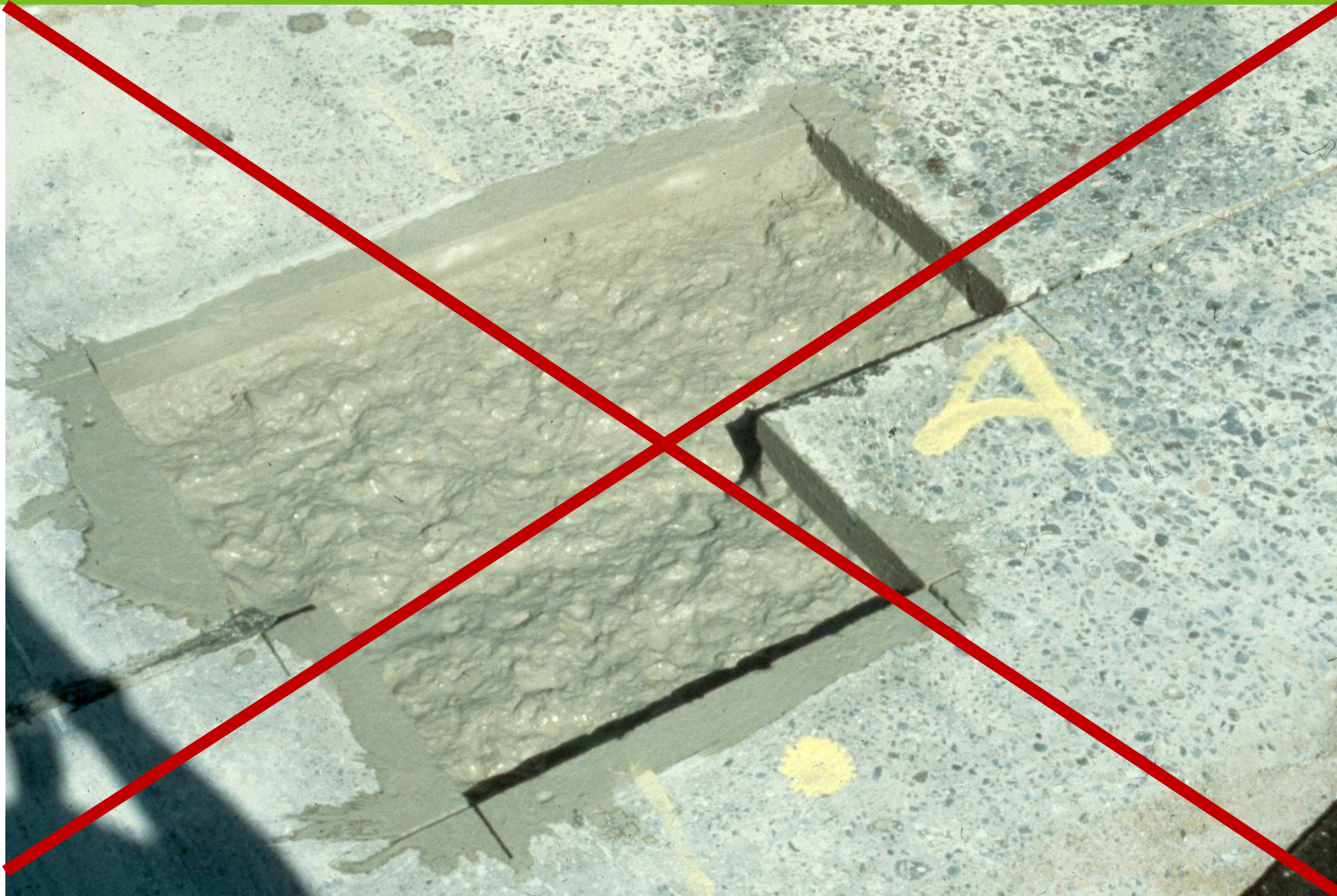
- Rock Pick
- Chain
- Paint Stick
- Tape Measure
- Wheel (0.1 ft accuracy)
- Quantity Worksheet for CPR
- Clipboard
- Knee pads for checking Type B Repairs

[Click on an image for a larger view.](#)

Sawn Vertical Perimeter



Sawn Vertical Perimeter



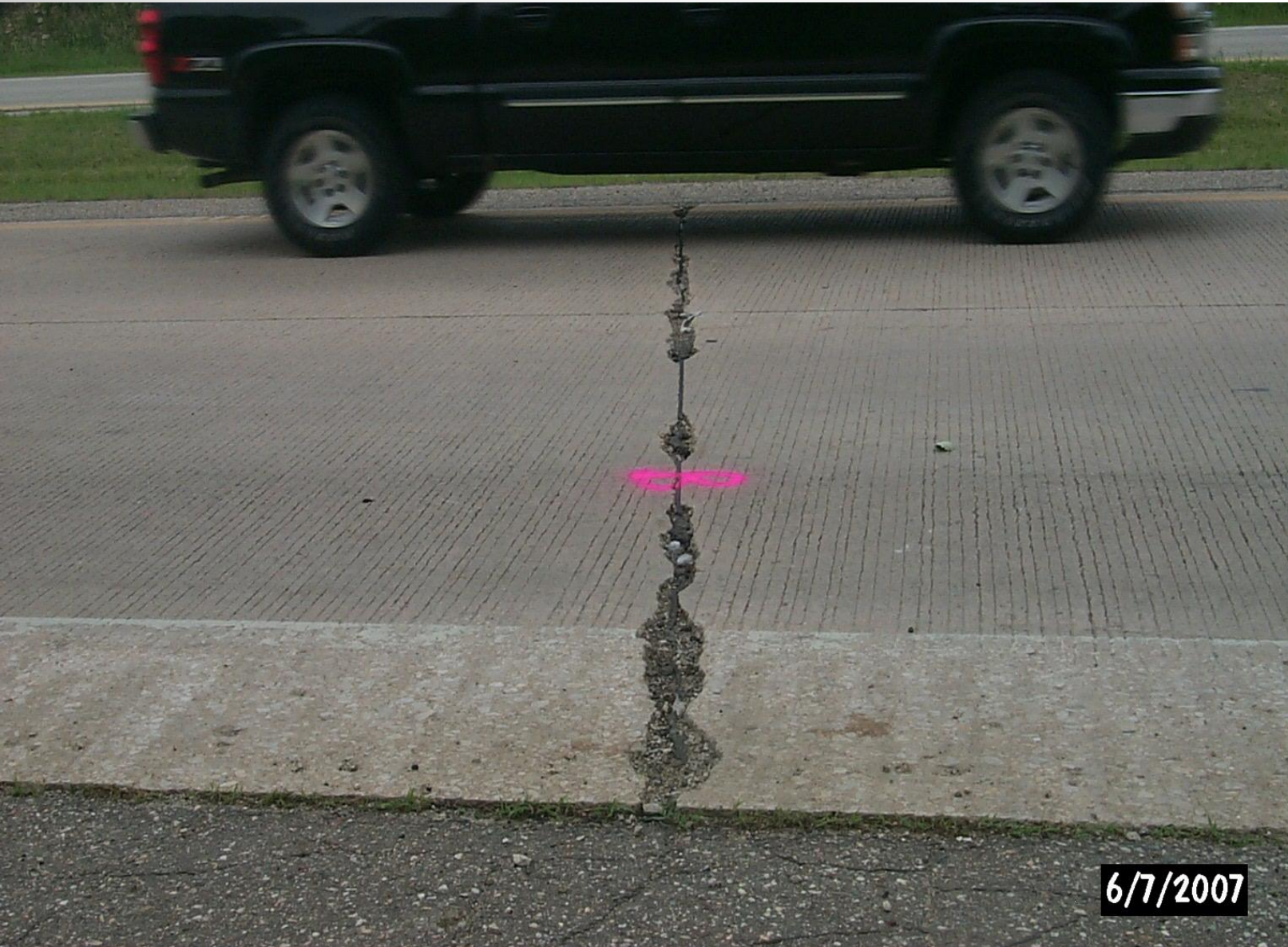
(Type BA) Repair

- Spot repair of localized spalling
- Repair delaminated areas above reinforcing steel and dowel bars
- Measured by area



(Type B3) Repair

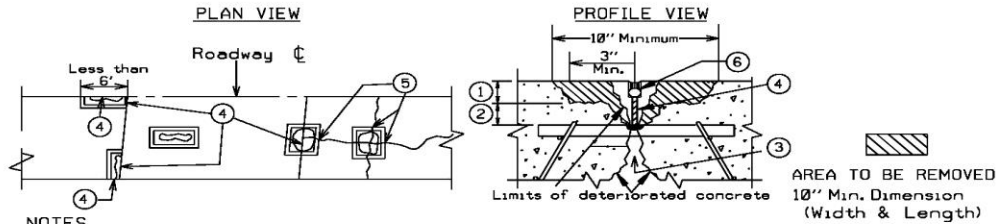
- Repair of joint spalling and transverse contraction joint tunneling
- Measured linearly



Partial Depth Repair (Type BA & B3)

PARTIAL DEPTH REPAIR (TYPE BA)

DESCRIPTION: REMOVE CONCRETE, REESTABLISH JOINTS AND CRACKS, FURNISH AND PLACE CONCRETE, SAW AND SEAL JOINTS AND CRACKS.



- NOTES**
- Joint and crack reestablishment is required. Furnish and install preformed joint filler prior to concrete placement.
 - Sawing for the initial joint establishment is not allowed.
 - Furnish preformed joint filler of a width equal to the existing transverse joint or crack $\frac{1}{4}$ " minimum thickness (Standard Spec. 3702). (4) Wax coated cardboard is allowed on cracks that are $\frac{1}{4}$ " or less in width. (5)
 - Chipping hammers are limited to a maximum weight of 35 pounds.

WORK TO BE DONE

1. Remove all concrete to limits shown in detail, including all unsound concrete by milling (1) and chipping hammers. (2) Taper all sides of the repair $30^\circ - 60^\circ$ from vertical and to a minimum depth of 2". (1)
2. If the end of the dowel bar is exposed, remove the dowel.
3. Clean exposed surface by sandblasting and air blasting
4. Place duct tape as a bond breaker on exposed dowel bars.
5. Provide joint compression relief in the void below the exposed dowel bar by furnishing and placing clean concrete sand level with the top of the dowel bars. (3)
6. Provide joint compression relief above the dowel bars by furnishing and installing preformed joint filler. (4)

AND / OR

Reestablish the crack through the repair by furnishing and installing wax coated cardboard. (5)

7. Apply bonding grout immediately prior to concrete placement. Re-sandblast and air blast if the bonding grout dries before the concrete is placed.

AND / OR

The Contractor may use water to precondition the in place concrete prior to placing concrete backfill. Reapply water if concrete dries prior to placing concrete backfill.

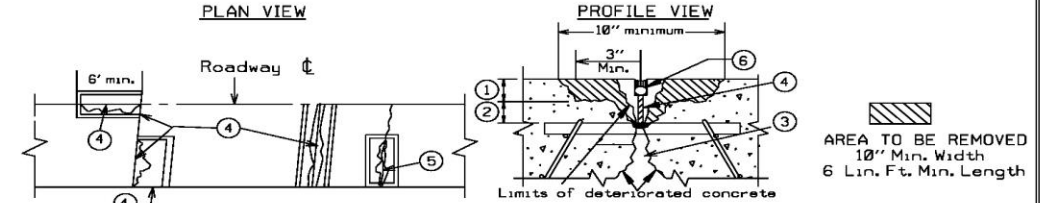
8. Furnish & place Concrete Mix Number 3U18. Vibrate, finish to grade and slope, edge adjacent to joint filler, Seal edges with grout and apply cure.
9. Saw and seal joints and cracks in accordance with Joint Repair (Type A1) detail. (6) (Incidental)

BASIS OF PAYMENT

2302 Partial Depth Repair (Type BA) (Sq. Ft.)

JOINT AND CRACK REPAIR (TYPE B3)

DESCRIPTION: REMOVE CONCRETE, REESTABLISH JOINTS AND CRACKS, FURNISH AND PLACE CONCRETE, SAW AND SEAL JOINTS AND CRACKS.



- NOTES**
- Joint and crack reestablishment is required. Furnish and install preformed joint filler prior to concrete placement.
 - Sawing for the initial joint establishment is not allowed when placed over random cracks.
 - Furnish preformed joint filler of a width equal to the existing transverse joint or crack $\frac{1}{4}$ " minimum thickness (Standard Spec. 3702). (4) Wax coated cardboard is allowed on cracks that are $\frac{1}{4}$ " or less in width. (5)
 - Chipping hammers are limited to a maximum weight of 35 pounds.

WORK TO BE DONE

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6. Provide joint compression relief above the dowel bars by furnishing and installing preformed joint filler. (4)

AND / OR

- 6A. Reestablish the crack through the repair by furnishing and installing wax coated cardboard. (5)

7. Apply bonding grout immediately prior to concrete placement. Re-sandblast and air blast if the bonding grout dries before the concrete is placed.

AND / OR

The Contractor may use water to precondition the in place concrete prior to placing concrete backfill. Reapply water if concrete dries prior to placing concrete backfill.

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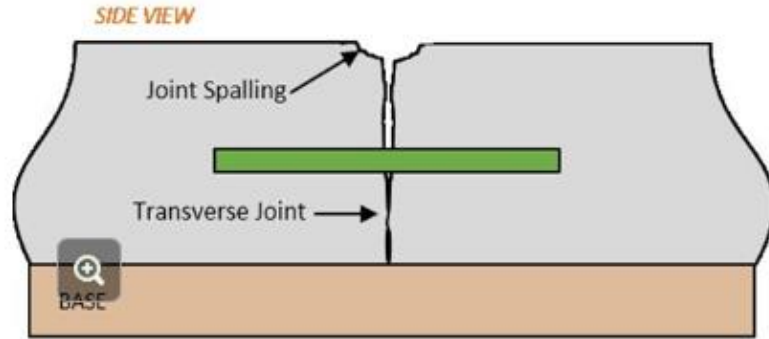
BASIS OF PAYMENT

2302 Joint and Crack repair (Type B3) (Lin. Ft.)

Type BA Repairs

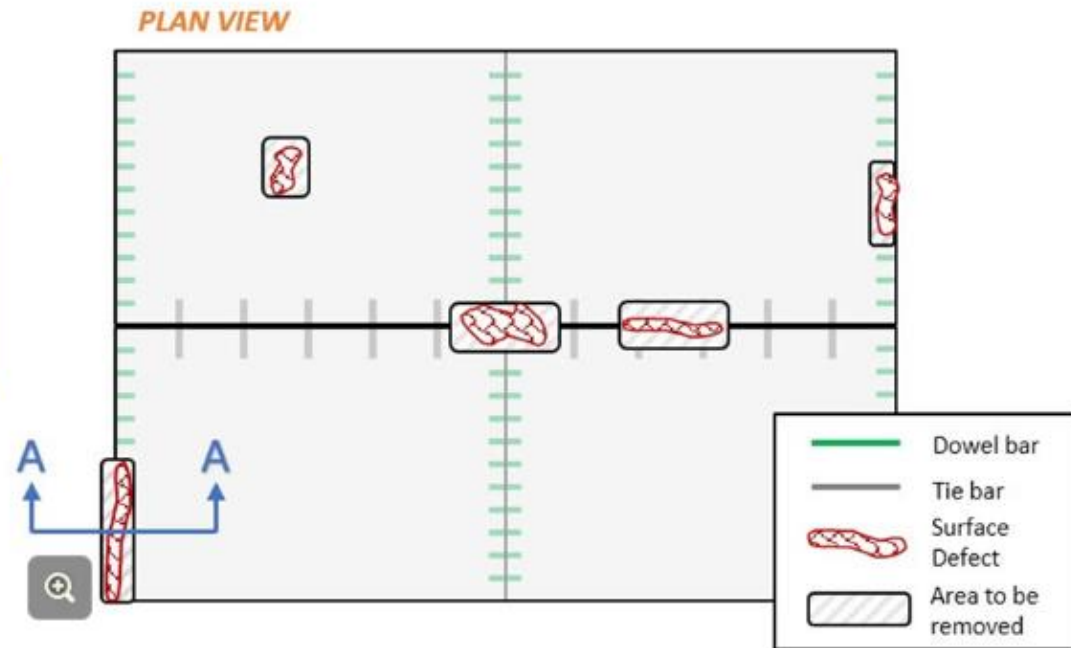
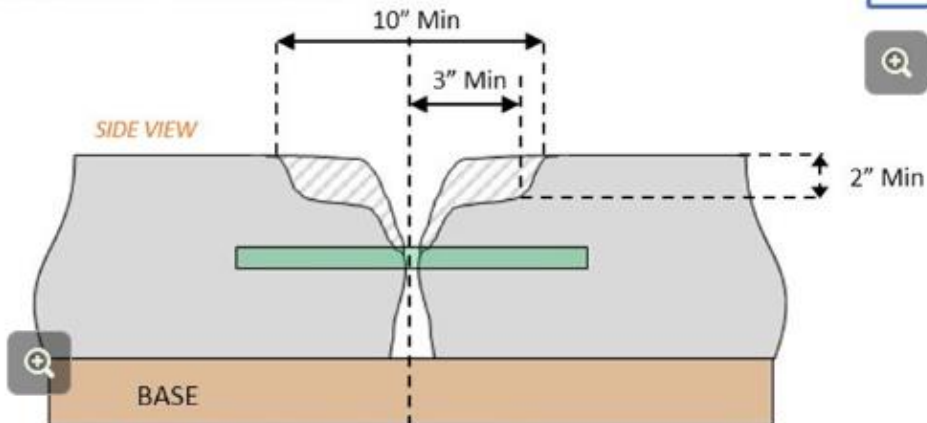
Repair Details – Dimensions and Common Locations

Click on an image for a larger view.



Minimum width: 10 inch (0.83 foot)
Minimum length: 10 inch (0.83 foot)
Maximum depth: Preferred above dowel/ tie bars - May extend deeper

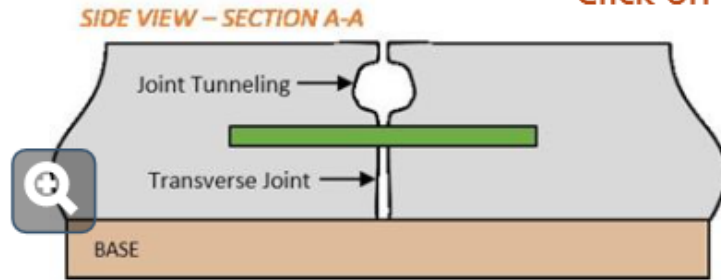
DIMENSIONS – SECTION A-A



Type B3 Repairs

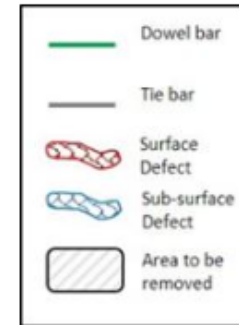
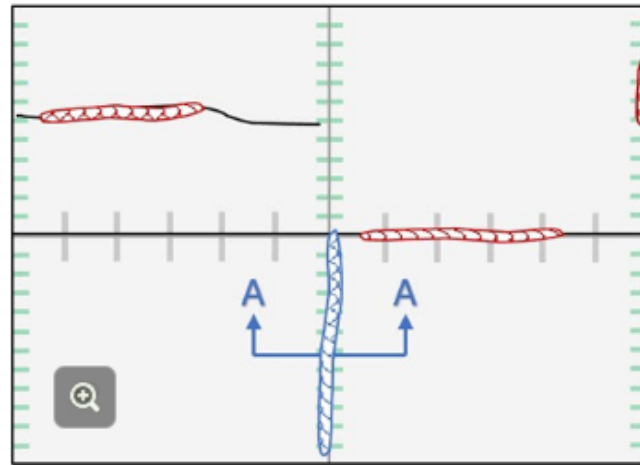
Repair Details – Dimensions and Common Locations

Click on an image for a larger view.

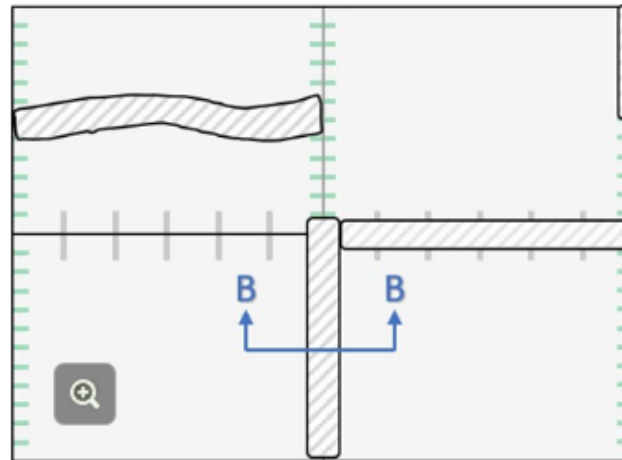
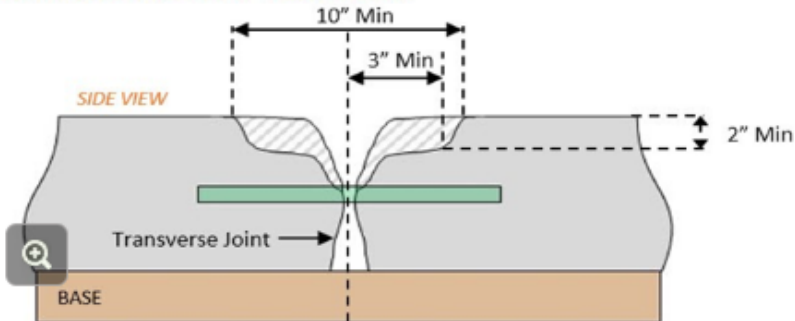


- **Minimum width:** 10 inch (0.83 foot)
- **Minimum length:** 6 feet
- **Maximum width:** Depends on the width of the cold mill grinding head, typically 10" to 15" after chipping is completed.
- **Maximum depth:** Preferred above dowel/tie bars, may extend deeper

PLAN VIEW



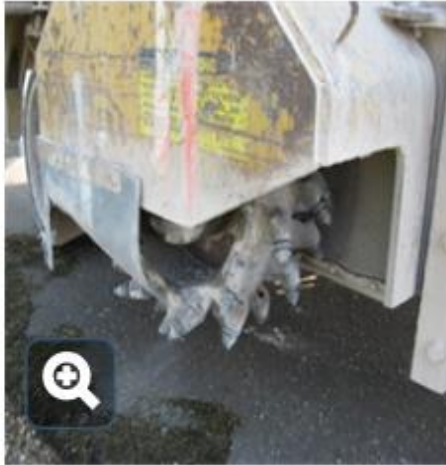
REMOVAL DIMENSIONS – SECTION B-B



Concrete Unit Recommendations

Do not start or end a Type B3 repair in a wheel path. If it does, extend the repair outside the wheel path. Wheel path is assumed to be 1.5 feet from a longitudinal joint and 1.5 feet wide.

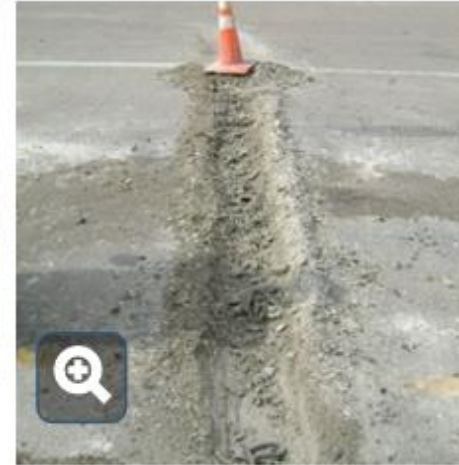
Click on an image for a larger view.



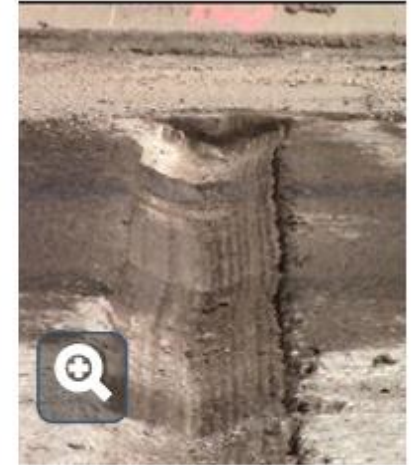
Carbide-tipped
Cold Milling Head



Milling Machine



Milled out
partial depth repair



Cleaned out partial
depth repair
prior to chipping

- Remove all unsound concrete by milling and chipping hammers.
- Contractors frequently use milling machines to speed up the removal process of partial depth repairs.
- Milling is not required, a Contractor can use only chipping hammers to remove concrete on partial depth repairs.
- Minimum Type B repair depth is two inches.

Click on an image for a larger view.



Chipping out
unsound concrete
and tapering edges
of the repair

Cleaning
concrete repair
with
compressed air

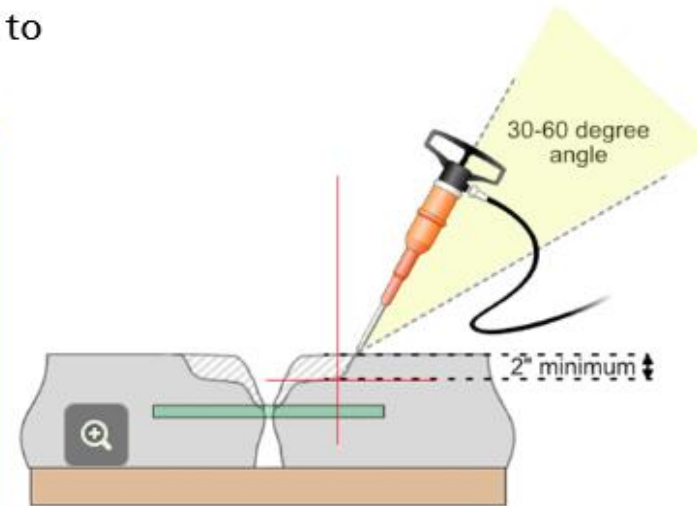


- The concrete patch is not bonded to the in-place concrete.
- Taper is too flat & irregular, maintain a consistent taper of 30 to 60° from horizontal and to a minimum depth of 2".



Chipping out unsound
concrete and tapering edges
of the repair

- After milling, chipping hammers are used for further remove unsound concrete.
- Chipping hammers are limited to a maximum weight of 35 pounds.
- Taper edges 30 to 60° from horizontal and to a minimum depth of 2 inches.
- The sides will be vertical when abutting a joint.





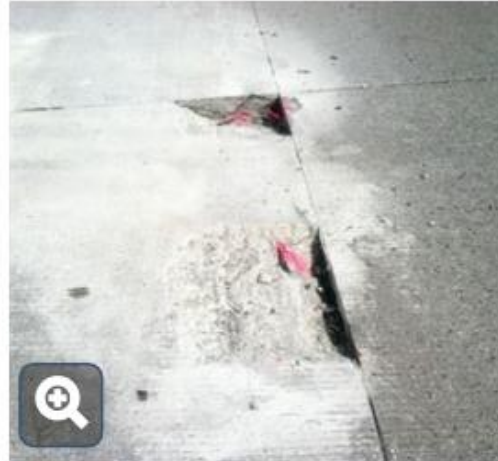
- The concrete patch is not bonded to the in-place concrete.
- Taper is too flat & irregular, maintain a consistent taper of 30 to 60° from horizontal and to a minimum depth of 2".



Using a straightedge (lath) to check partial depth repair is a minimum of 2" deep



If the end of the dowel bar is exposed, remove the dowel bar (indicated by circle)



Misplaced tie bars painted pink for removal.



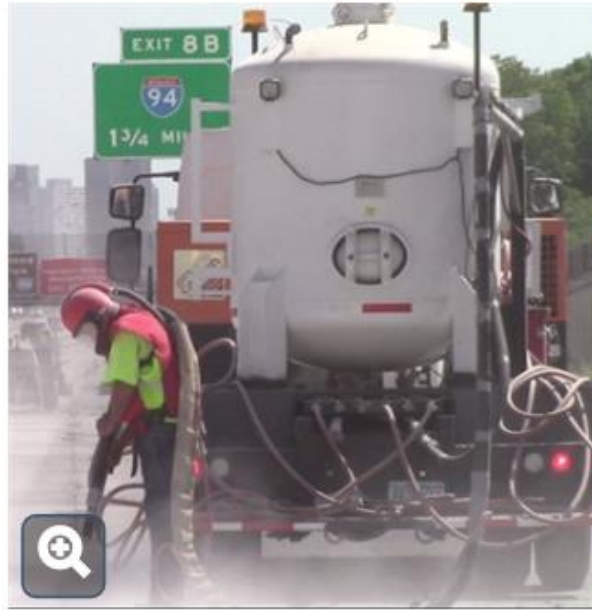
Misplaced reinforcing steel and exposed dowel bar.



Inspector checking removal area for unsound concrete, misplaced steel, exposed dowel bar ends, and 30° to 60° tapered edges.



Removing misplaced steel.



Sandblasting partial depth repairs

All Type B Repairs:

- Sandblasting the exposed surface is critical to remove laitance and other debris that will prevent bonding.
- If it rains prior to concrete backfilling, re-sandblast the exposed surfaces.

Concrete Unit Recommendations

The nozzle operator will need to use multiple shot angles to thoroughly clean the bonding surfaces of the Type B repairs.

Click on an image for a larger view.



Compressed air blasting the repairs



Maintenance crew using compressed air for final cleaning.



Leaf blower

After sandblasting, the final cleaning crew will use compressed air or leaf blowers to clean the surface prior to application of the bonding agent.

Concrete Unit Recommendations

Ensure there is no sandblast or removal debris prior to application of the bonding agent.



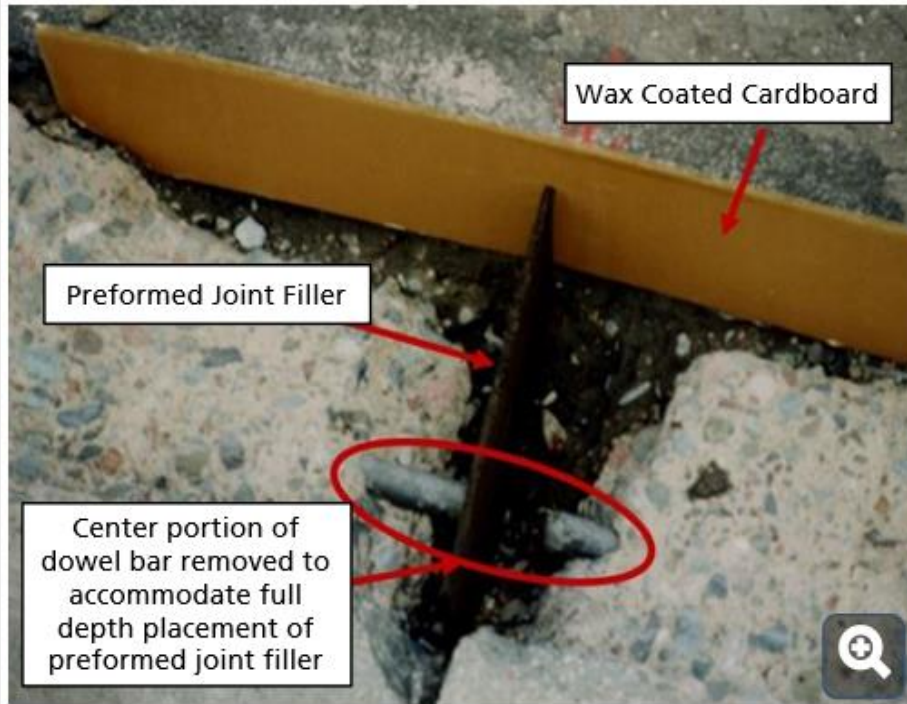
Applying duct tape to exposed dowel bars



- To prevent the concrete patch mix from sticking to the dowel bars, use duct tape as a bond breaker.
- Form release oil is not an acceptable bond breaker.

Type BA Repairs

Repair Preparation – Compression Relief for Joint Re-Establishment



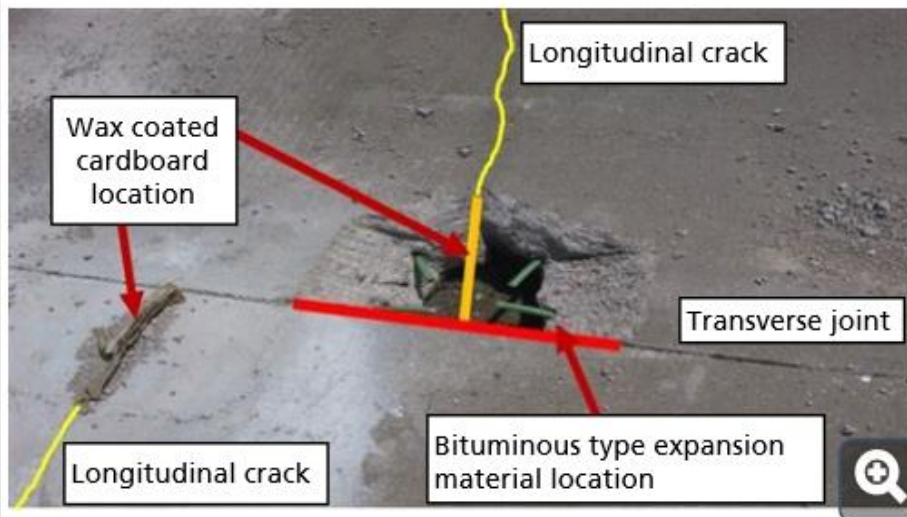
Compression relief material should extend to the bottom of the partial depth repair in a single piece.

Refer to the MnDOT Approved Products website for a list of MnDOT Approved Preformed Joint Fillers – Spec 3702.

<http://www.dot.state.mn.us/products/concrete/preformedjointfillers.html>



Notice how expansion material is trimmed to fit properly in the joint or crack

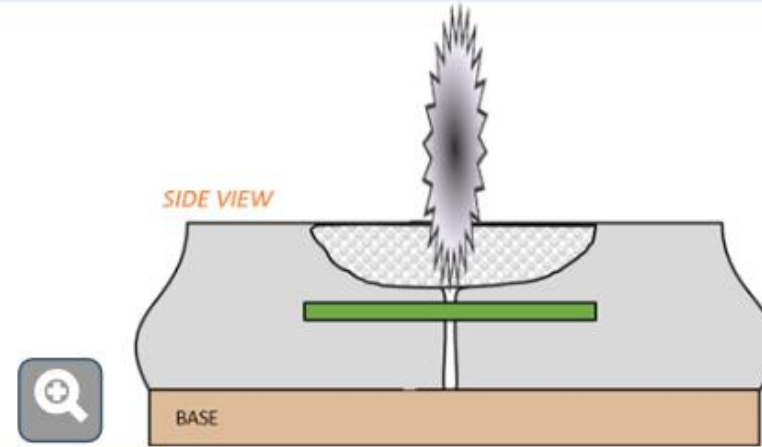


Concrete Unit Recommendations

Using preformed joint filler or wax coated cardboard is the typical method used by Contractors for joint re-establishment.



Tooling the joint in preparation for green sawing



- Do not saw for joint re-establishment if
- Type B repair depth extends below the top of the dowel bars or
 - Type B repair is used to repair a random crack.

Sawing for Joint Re-Establishment

The Engineer may allow sawing for joint re-establishment when **ALL** of the following conditions exist:

1. Precautions are taken to prevent infiltration of concrete into underlying joint.
2. Depth of the entire Type B repair remains above dowel bars.
3. In order to prevent compression spalls, saw cut the entire depth of the Type B repair.
4. Green sawing takes place in a timely manner, to prevent random cracks.
5. Green sawing does not produce excessive spalling.

Concrete Unit Recommendations

If the Contractor elects to saw for joint re-establishment, ensure the saw cut goes completely through the depth of the repair patch.

Click on an image for a larger view.



Re-establishing joint above random crack with wax coated cardboard.



Re-establishing both transverse and longitudinal joints using wax coated cardboard

Concrete Unit Recommendations

- Hold the wax coated cardboard or preformed joint filler vertically when concrete backfilling and vibrating.
- Vibrate on both sides of the wax coated cardboard or preformed joint filler

Transverse Contraction joint



Popout & Breakage



Expansion ➡ ⬅ Expansion

No Relief at Contraction Joints

Type BA Repairs Repair Preparation – Importance of Compression Relief



Compression relief not installed at time of construction resulted in compression failure
(Picture taken 1 year after installation)

Type BA Repairs Repair Preparation – Importance of Compression Relief X



Compression relief not installed at time of construction resulted in compression failure
(Picture taken 1 year after installation)



Compression relief not installed at time of construction resulted in compression failure
(Picture taken 1 year after installation)

- Partial Depth Repair Mix 3U18
 - Concrete aggregate 100% passing 3/8" sieve
 - Concrete Sand
 - Type I Cement
- Pre-bagged mix design proportions per Spec 3105
 - Delivered in 50#, 75# and 3000# pre-bagged mixes bag or batched on site
 - Field proportioned mix design per Spec 2302
- Partial Depth Repair Mix 3U18 Specs:
 - 6.5% air entrainment (**added on site**)
 - Maximum 1 inch slump
 - Cure time of 12 hours
- **Ready Mix is NOT Allowed**

Click on an image for a larger view.



Mixing 3000# bulk bags of 3U18



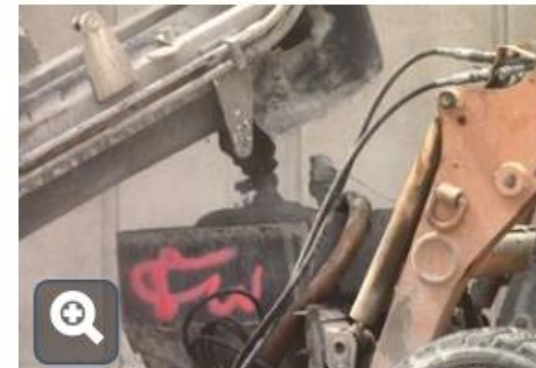
Back of truck concrete mixer for pre-bagged 3U18 mixes



3U18 MnDOT Pre-bagged mix



Volumetric proportioning of 3U18 with mobile mixer

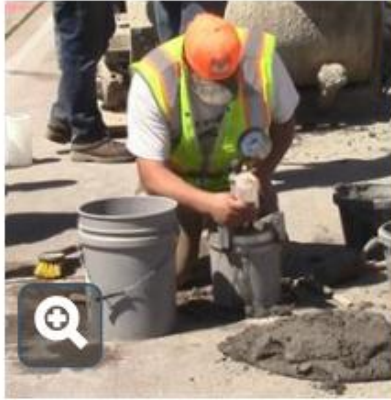


Discharging 3U18 from mobile mixer into skid steer bucket

Concrete Unit Recommendations

Concrete backfill operations should follow closely behind application of bonding agent.

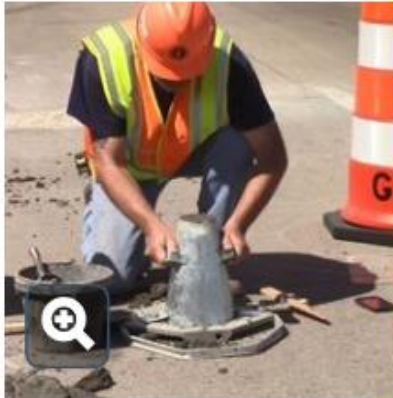
Click on an image for a larger view.



- Measure the air content of 3U18 to verify compliance with a specified target of 6.5 percent (+2.0 percent and –1.5 percent)



- Fabricate a set of 3 cylinders for 28 day compressive strength testing.
- Fabricate field control cylinders to determine when to open the repair to traffic.



- After batching, allow mix to hydrate 5 minutes before performing the slump test.
- Measure slump to verify compliance of a maximum one inch slump.



- Take ambient (air) and concrete temperature measurements.

How-to videos for concrete field testing can be found here:
<http://www.dot.state.mn.us/materials/concretevideo.html>

Concrete Unit Recommendations

- Test in accordance with the MnDOT Schedule of Materials Control found in Contract.
- Cast field control cylinders within the last hour of concrete placement
- **Slump testing is critical to ensure the Contractor is controlling the water content in the 3U18 concrete mix**

Click on an image for a larger view.



Bonding Grout/Slurry Method

- Prior to concrete backfilling, apply bonding grout to the sandblasted concrete surface.
- The bonding grout/slurry consists of water, cement and sand.
- After applying the grout, immediately backfill repair with concrete.
- **Re-sandblast and air blast if the bonding grout dries/whitens before the concrete is placed.**
- The pot life of the bonding grout shall not exceed one hour.



Water Bonding Method

- Prior to concrete backfilling, apply potable water to the sandblasted concrete surface.
- Remove standing water within the repair.
- Reapply water if concrete surface dries prior to backfilling.

Concrete Unit Recommendations

Ensure there is no sandblast or removal debris prior to applying bonding grout or water to the concrete surface.

Click on an image for a larger view.



Applying bonding grout to the partial depth repair

Concrete Unit Recommendations

Concrete backfill operations should follow closely behind application of bonding agent.

Click on an image for a larger view.



Placing 3U18 concrete patching mix just after applying bonding grout.



Vibrating 3U18 patching mix.



Placing, vibrating, and finishing 3U18 concrete patching mix



Finishing and edging partial depth repairs.



Close up of finishing partial depth repair



Edging adjacent to wax coated cardboard

Concrete Unit Recommendations
To not pull the concrete mix away from the edges, finish the concrete from the middle of the repair outward.



Provide a repaired surface tolerance that does not vary by more than 1/8 inch from the existing pavement surface as measured with a straight edge placed over the repair. Replace or grind the repair as necessary to correct deficiencies.

Slurry Protection

Type BA Repairs Concrete Placement – Texturing and Applying Sacrificial Grout Layer

Type BA Repairs Concrete Placement – Texturing and Applying Sacrificial Grout Layer

Click on an image for a larger view.



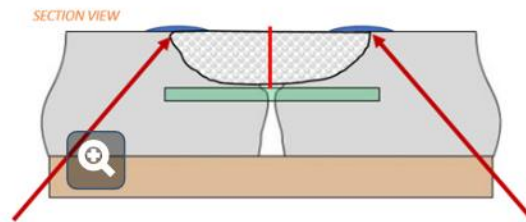
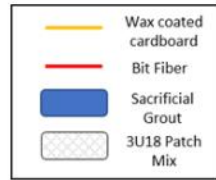
Broom texture for skid resistance



Applying sacrificial grout layer over tapered edges



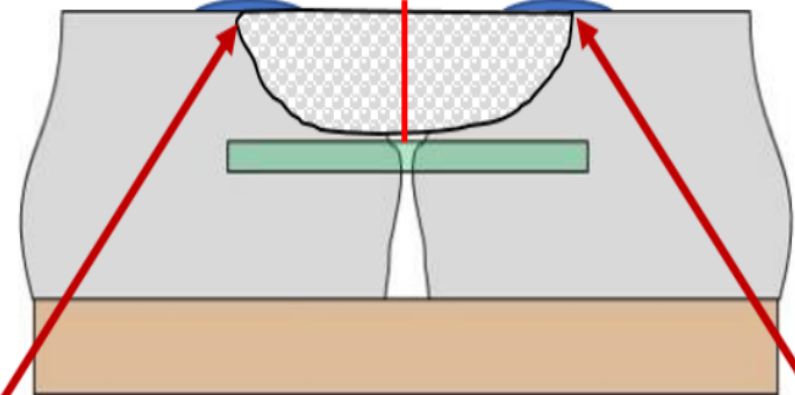
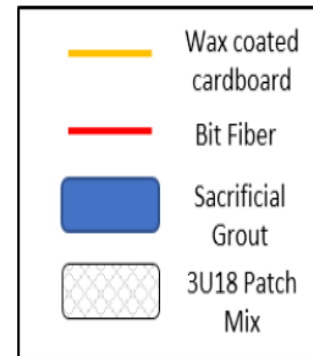
Sacrificial grout layer over taper edges one year later.



The purpose of this sacrificial grout coating is to prevent the mixture from drying out prematurely on tapered edges of the repair.

X

SECTION VIEW



The purpose of this sacrificial grout coating is to prevent the mixture from drying out prematurely on tapered edges of the repair.



Type B3 repair with curing compound applied uniformly (equal to a white sheet of typing paper)

Apply the AMS or linseed oil membrane curing compound within 10 minutes of final finishing.

Refer to the MnDOT Approved Products website for a list of MnDOT Approved Curing Compounds Spec 3754 or 3755 <http://www.dot.state.mn.us/products/concrete/curingcompounds.html>



Wherever possible, Square Partial depth repairs into squares or rectangles. Radiused corner is common practice.

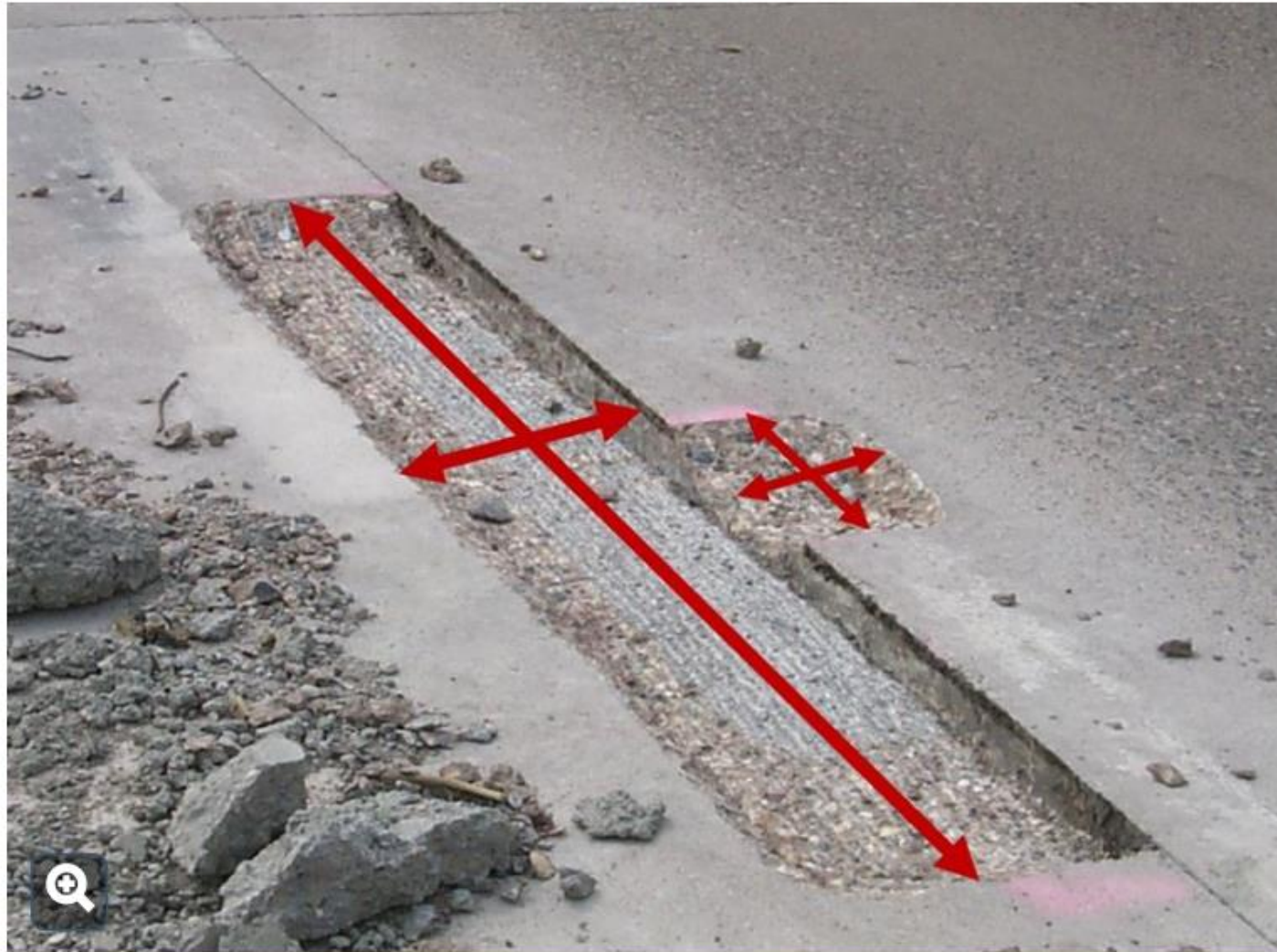


If the repair is an irregular shape, measure the area by averaging the narrowest and widest widths of the repair and multiplying by the length.

Paid for as Type BA by the square foot

Take the measurements for the area calculations at the pavement surface; include the 30 to 60 degree tapers in the measurements for the area calculations.

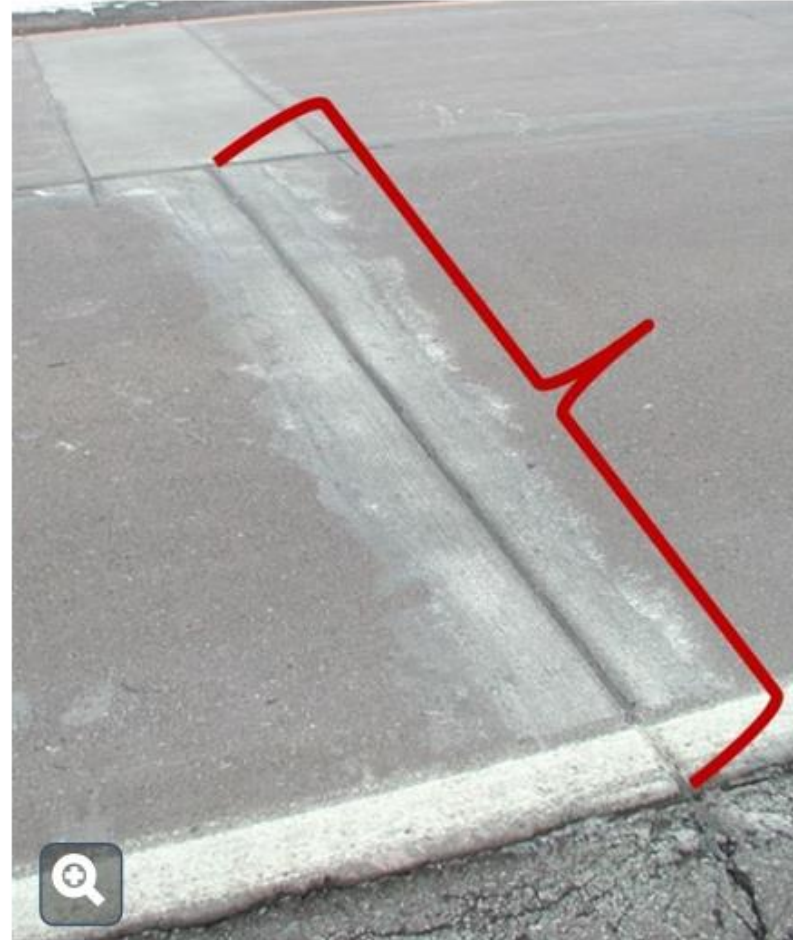
Click on an image for a larger view.



Combination of two Type BA Repairs

Take the measurements for the area calculations at the pavement surface; include the 30 to 60 degree tapers in the measurements for the area calculations.

Click on an image for a larger view.



Paid for as Type B3 by the linear foot

Take measurements along the lineal length of the joint or crack.

Note: These repairs could also be paid for as Partial Depth Repair (Type BA) by the square foot.

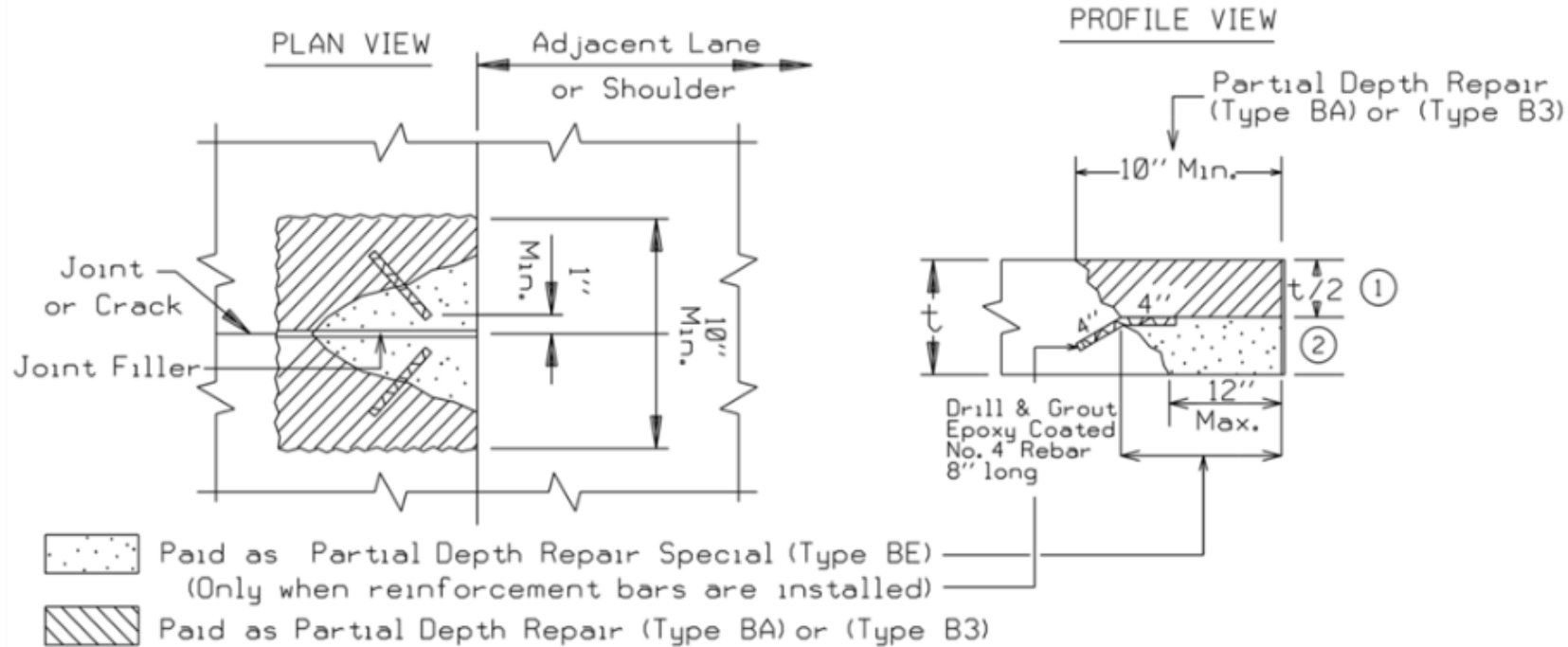


The inspector determined there was too much deterioration at the bottom of the repair and switched the Type B3 repair to a Full Depth Type CD repair (note pink marking on pavement).

The Engineer would have to pay 40% of the Type B3 repair cost and 100% of the Type CD repair cost.

PARTIAL DEPTH REPAIR SPECIAL (TYPE BE)

DESCRIPTION: REMOVE CONCRETE, INSTALL REINFORCEMENT BARS, FURNISH & PLACE CONCRETE, SAW AND SEAL JOINTS.



NOTES

- Do not use this repair in the wheel paths, use the Full Depth Repair (Type CD).
- Joint and crack reestablishment is required. Furnish and install preformed joint filler prior to concrete placement.
- Sawing for the initial joint establishment is not allowed.
- Furnish joint filler in a single piece for the full depth of the repair.
- Furnish preformed joint filler of a width equal to the existing transverse joint or cracks $\frac{1}{4}$ " minimum thickness (Standard Spec. 3702). Wax coated cardboard is allowed on cracks that are $\frac{1}{4}$ " or less in width.
- Chipping hammers are limited to a maximum weight of 35 pounds.

Type BE Repairs

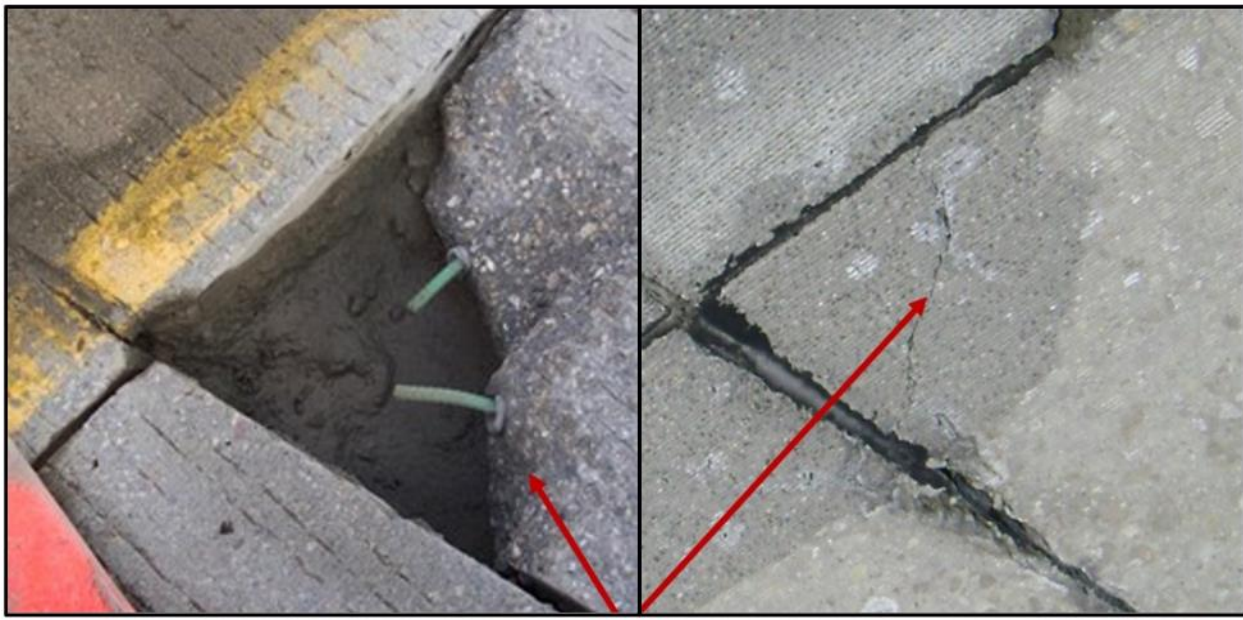
How to Perform

- Repair of localized bottom-up deteriorations
- Primarily found at intersecting longitudinal and transverse contraction joints and below longitudinal Joints
- Measured by area
- Always paid for in conjunction with a Type BA or B3 repair



Repair Evaluation Period

Reflective Cracking in Type BE Repairs



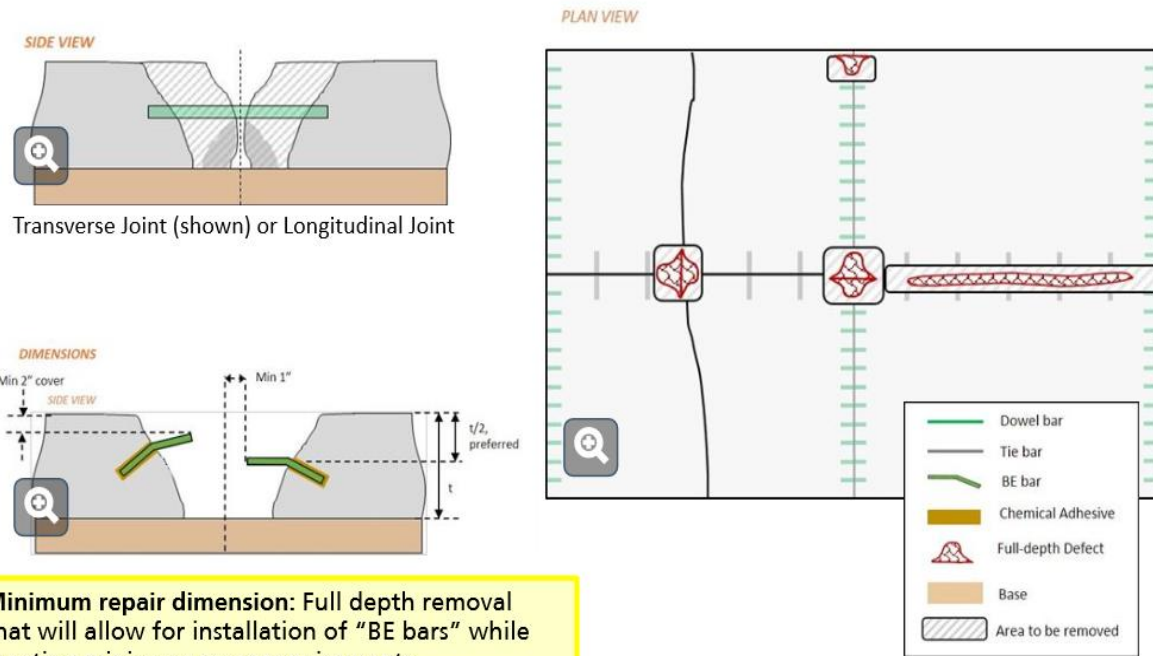
- Reflective cracks often appear at sudden thickness differentials within a BE repair.
- Likely cause was either no BE bars were installed. Or, an inadequate number of BE bars were installed.
- Remove and replace this type of failure.

Concrete Unit Recommendations

- Space BE bars a maximum of 6 in center-to-center.
- Experience has shown installing an inadequate number of BE bars will reduce the life expectancy of a BE repair

Type BE Repairs

Repair Details – Dimensions and Common Locations



Minimum repair dimension: Full depth removal that will allow for installation of "BE bars" while meeting minimum cover requirements.

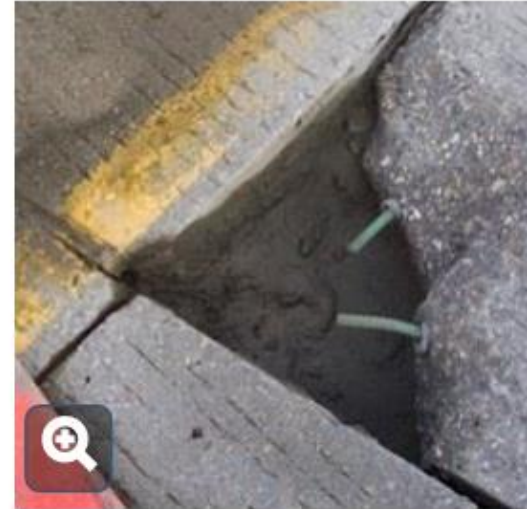
Concrete Unit Recommendations

If the Type BE repair projects into the wheel path, consider changing to a full depth repair.

Type BE Repairs

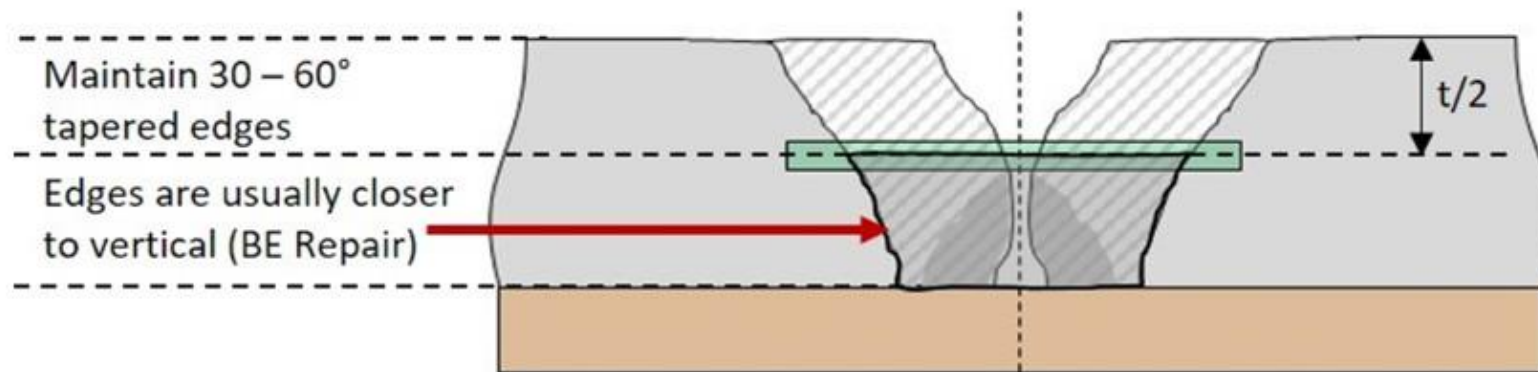
Concrete Removal by Chipping Hammers

Click on an image for a larger view.



Chipping hammers are used for concrete removal below mid-depth of pavement ($t/2$)

Type BE repairs are commonly found at intersections of transverse and longitudinal construction joints

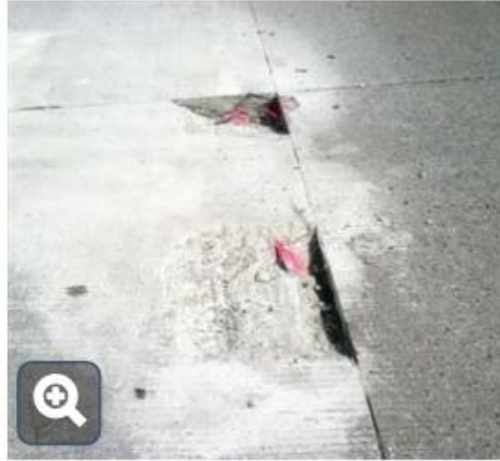


Transverse Joint (shown) or Longitudinal Joint





If the end of the dowel bar is exposed, remove the dowel bar (indicated by circle)



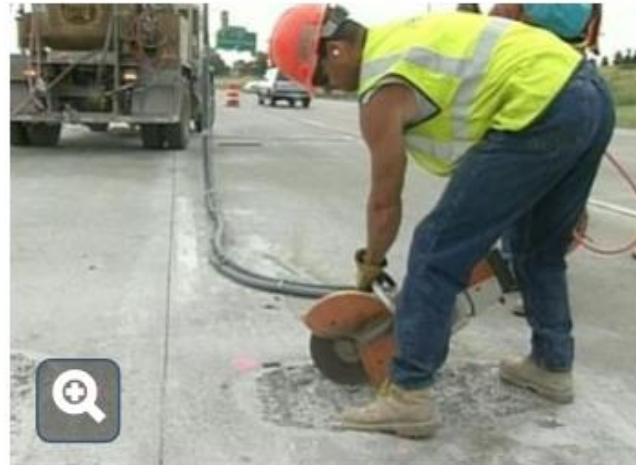
Misplaced tie bars painted pink for removal.



Misplaced reinforcing steel and exposed dowel bar.



Inspector checking removal area for unsound concrete, misplaced steel, exposed dowel bar ends, and 30° to 60° tapered edges.



Removing misplaced steel.



By marking "BE" on the pavement, the Inspector is instructing the Contractor to drill and grout 8-inch long No. 4 rebars (BE bars)

Click on an image for a larger view.



Enlarge Type BA/B3 Repair as needed to maintain 30 – 60 ° tapered edges



If the end of the dowel bar is exposed, remove the dowel bar at the joint



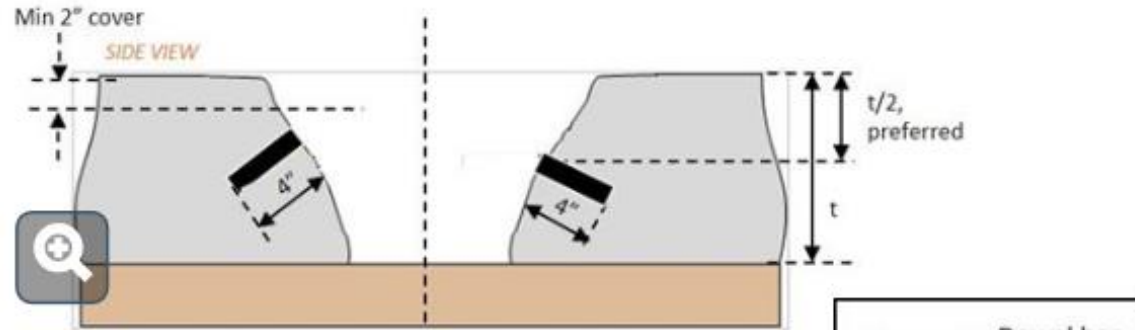
Cut the BE bars to maintain 1-inch minimum cover

If the end of the dowel bar is exposed, remove the dowel bar at the joint

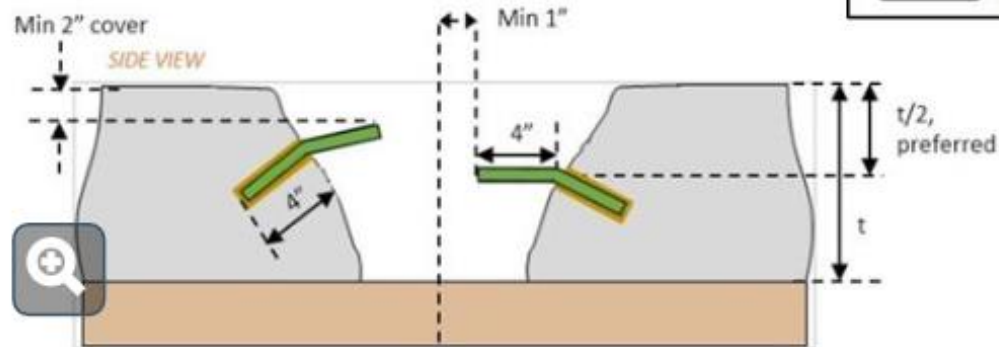
BE bars should not cross a transverse contraction joint



This is not the intent of a Type BE repair. If three or more dowel bars require removal, the partial depth repair should be changed to a full depth repair. NOTE: The Engineer would then have to pay 40% of the partial depth repair and 100% of the full depth repair.



Use 5/8" drill bit to drill holes 1/8" larger than the diameter of the No. 4 BE bar



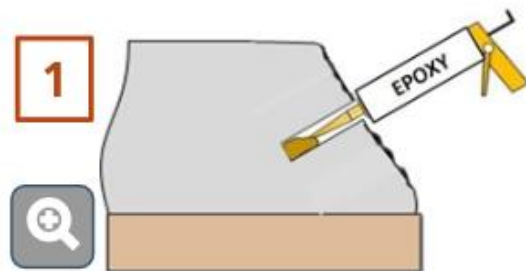
- Maintain minimum concrete cover around BE bar



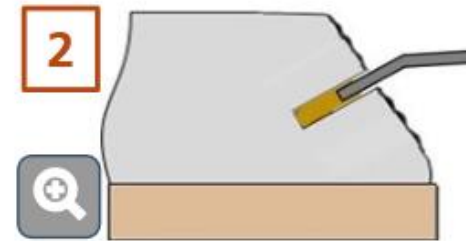
Drilling 1/8" oversized holes

Type BE Repairs

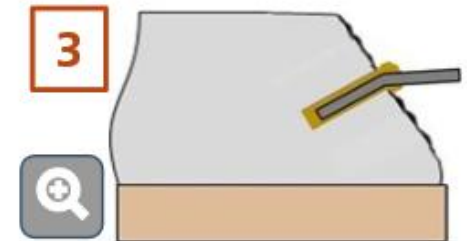
Repair Preparation - Drill & Grout Reinforcement Bars for Type BE Repairs



- 1
- Fill the back of the hole (1/2 to 3/4 full) with a chemical adhesive (non-shrink grout or epoxy).
 - Count the number of pumps of adhesive into the drill hole.



- 2
- Insert epoxy coated 8 inch long No. 4 rebar (BE bars) into the hole.
 - If no adhesive is expelled, repeat Step 1 by filling the hole with a greater number of pumps



- 3
- Installed BE bar ensuring expelled chemical adhesive

Install the "BE bars" using a MnDOT approved epoxy adhesive or non-shrink grout product.

Refer to the MnDOT Approved Products website for a list of MnDOT Approved Concrete Anchorages – Adhesive/Epoxy Product.

<http://www.dot.state.mn.us/products/concrete/concreteanchorages.html>

Refer to the MnDOT Approved Products website for a list of MnDOT Approved Non-Shrink Grouts.

<http://www.dot.state.mn.us/products/concrete/nonshrinkgrouts.html>

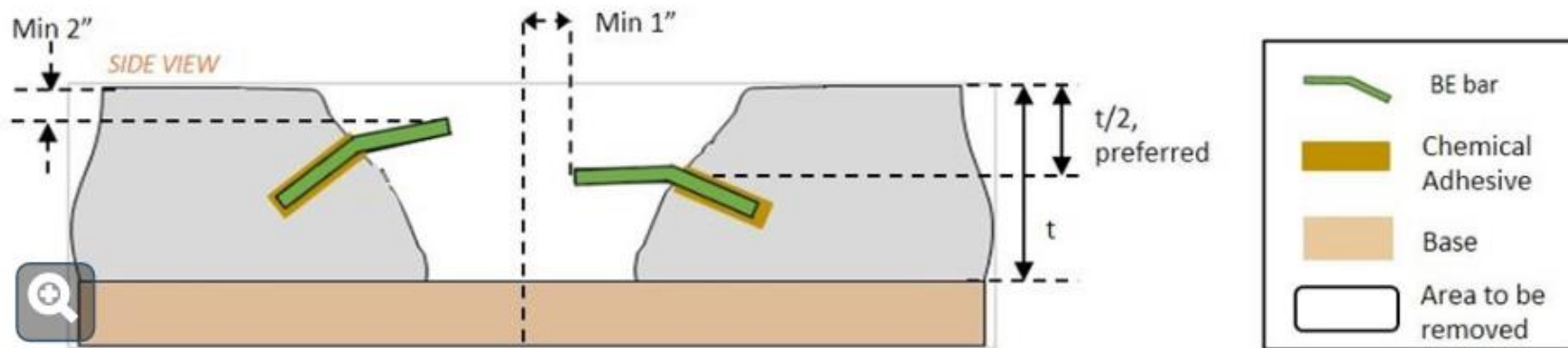


This is a well executed BE repair:

- 2" minimum cover maintained above the bar
- Adequate number of BE bars installed
- Visually see epoxy adhesive around BE bars
- The BE part of the repair is out of the wheel path.

This is an unacceptable BE repair:

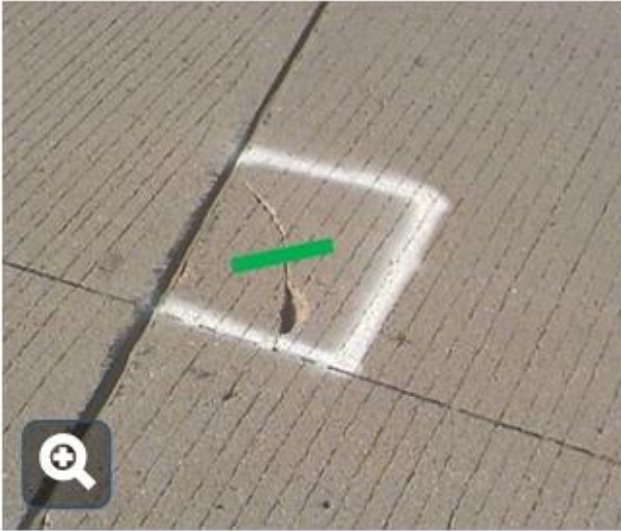
- Insufficient number of BE bars installed
- BE repair extends into the wheel path
- Edges are not tapered 30 – 60 degrees.



Concrete Unit Recommendations

Ensure BE bars have a minimum 2" of cover above the bar and 1" of cover from the bar to the adjacent joint.

Click on an image for a larger view.



Reinforcement steel is needed to bond the concrete patch to a sub-vertical face. Otherwise we are replacing a chunk of loose concrete with a future chunk of loose concrete.



- Reflective cracks often appear at sudden thickness differentials
- Ensure BE bars are installed in locations where minimum cover allows



Concrete Unit Recommendation

Pay a minimum of one square foot of Type BE repair whenever at least one BE bar can be installed.
(Don't be cheap. You will regret it.)

Paid for as Type BE by the square foot

Take measurements for the Type BE area calculation at mid depth of the concrete pavement.

The Engineer will take measurements for the Type BE **only** when the following requirements are met:

- ✓ (1) When the in-place concrete pavement is removed full depth and when the grade below the concrete pavement is visible
- ✓ (2) When reinforcement bars are furnished and installed as shown in Partial depth repair special (Type BE) detail and at least one reinforcement bar is installed per unit of measure.

The Partial Depth Repair Special (Type BE) is not a stand alone repair. The area in yellow is paid as a Type BE repair and a Type BA repair.





Sawing a Type B Repair



Sealing along a Type B repair

Thank You!

gordon.bruhn@state.mn.us

651-398-9597