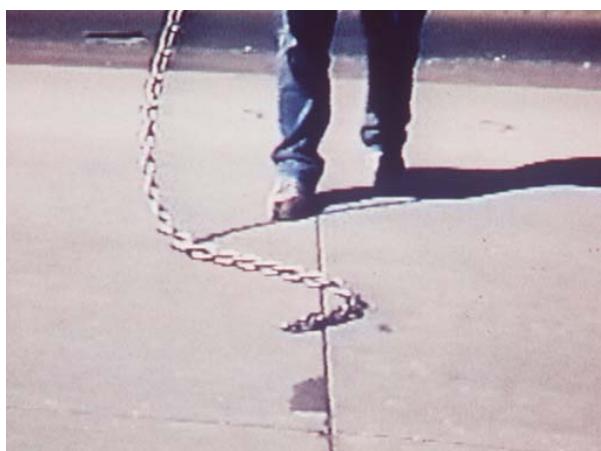


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**CONCRETE PAVEMENT REHABILITATION  
5-694.900****5-694.901 GENERAL**

Concrete Pavement Rehabilitation is an extremely valuable tool of the Minnesota Department of Transportation in an effort to maintain our concrete pavements. The repair standards were developed in the early 1980's and revised yearly since. Great strides in technology were made in the first years, while more recently the changes have been minor as current techniques are now working well.

**Note:** It is recommended that the Engineer perform an investigation into the soundness of pavement before specific repairs are decided upon. This investigation should include chain dragging and hammering the concrete surface to locate delaminated areas of pavement, coring, and possibly milling some joints to determine the severity of deterioration, and coring near and away from joints to test for freeze-thaw durability. See Figures A through C 5-694.901 for methods and tools used in identifying concrete pavement deterioration.

**Figure A 5-694.901****Figure B 5-694.901****Figure C 5-694.901**

The rehabilitation standards are available on the Mn/DOT Concrete Engineering Unit website at [www.mrr.dot.state.mn.us/pavement/concrete/rehab.asp](http://www.mrr.dot.state.mn.us/pavement/concrete/rehab.asp). The Special Provisions are located on the Office of Technical Support website. Audio-visual training aids are available by contacting the Mn/DOT Concrete Engineering Unit at 651-779-5576.

## **REPAIR TYPES**

Mn/DOT breaks down concrete repairs into four basic types. The major areas of concrete pavement rehabilitation are partial depth patching, full-depth patching, slab replacement, joint/crack sealing. Other specialized repairs include Continually Reinforced Concrete Pavement (CRCP), retrofitting load transfer with dowel bars and texture planing concrete surfaces to restore ride (diamond grinding). Edge drains and shoulder replacement are other rehabilitation techniques that are sometimes added, although they are not discussed here.

### **5-694.910 TYPE A REPAIRS – JOINT AND CRACK SEALING**

The letter "A" designates joint and crack sealing repairs. The term joint sealing is generic for sealing joints and cracks. These repairs include sawing and cleaning the concrete joint or crack face to provide a proper surface and shape factor to ensure adhesion of the sealer. Joints wider than 25 mm (1in.) may increase tire slapping. See Figures A and B 5-694.912 for examples of candidates for Type A repairs.

More information about joint sealing is available in Section 5-694.665 of this Manual.

### **5-694.911 JOINT AND CRACK SEALING PROCEDURES**

The procedures are the same whether the joint or crack is in place or re-established. The joint is sawed to the shape specified in the plan. This operation includes water flushing. Before sealing, the joint/crack is cleaned by sand blasting and air blasting. The proper size, closed cell backer rod is then placed and the joint sealed with either silicone or hot pour sealant.

### **5-694.912 IMPORTANT POINTS OF JOINT AND CRACK SEALING**

A perfectly clean and dry joint face is necessary for good adhesion. This is imperative for a successful joint sealing project. A proper joint shape is necessary for the seal to work properly. The shape is shown in the plans. The following is a list of Type A Repairs.

#### Type A-1H

Saw and reseal transverse contraction joints with hot pour sealant. See Figure C 5-694.912 for an example of a Type A-1H repair.

#### Type A-1S

Saw and reseal transverse contraction joints with silicone sealant.

**Type A-2**

Clean and seal/reseal transverse joints with hot pour or crumb rubber sealant. This is not recommended for high volume roads.

**Type A-3H**

Saw and seal cracks, or those portions of cracks, between 3 mm (1/8 in.) and 13 mm (1/2 in.) wide with hot pour sealant. Cracks less than 3 mm (1/8 in.) wide are generally not repaired.

**Type A-3S**

Saw and seal cracks, or those portions of cracks, between 3 mm (1/8 in.) and 13 mm (1/2 in.) wide with silicone sealant. Cracks less than 3 mm (1/8 in.) wide are generally not repaired.

**Type A-4H**

Saw and seal cracks, or those portions of cracks, between 13 mm (1/2 in.) and 25 mm (1 in.) wide with hot pour sealant. For cracks wider than 25 mm (1 in.), use Repair Type B-1.

**Type A-4S**

Saw and seal cracks, or those portions of cracks, between 13 mm (1/2 in.) and 2 mm (1 in.) wide with silicone sealant. For cracks wider than 25 mm (1 in.), use Repair Type B-1. See Figure D 5-694.912 for an example of a Type A-4S repair.

**Type A-5H**

Saw and seal/reseal non-spalled portions of untied longitudinal joints with hot pour sealant. It is not intended for tied centerline type joints.

**Type A-5S**

Saw and seal/reseal non-spalled portions of untied longitudinal joints with silicone sealant. It is not intended for tied centerline type joints.

**Type A-6**

Saw and seal/reseal non-spalled portions of tied longitudinal joints with hot pour sealant.

**Type A-7H**

Clean and seal cracks of 13 mm (1/2 in.) or less with hot pour sealant.

**Type A-7S**

Clean and seal cracks of 13 mm (1/2 in.) or less with silicone sealant.



**Figure A 5-694.912**



**Figure B 5-694.912**



**Figure C 5-694.912**



**Figure D 5-694.912**

**5-694.920 TYPE B REPAIRS – PARTIAL DEPTH REPAIRS**

Type B repairs generally consist of partial depth milling or chipping to remove deteriorated or delaminated concrete and preparation and placement of the repair. Type B-2D and B-2E repairs include removal to the bottom of the pavement if necessary.

**5-694.921 PARTIAL DEPTH PROCEDURES**

The removal area is defined by chain dragging and hammering the surface to find the complete limits of delamination. The area is then marked out clearly for the Contractor. The unsound concrete is generally milled (though chipping is allowed) a minimum of 50 mm (2 in.) and a maximum of the top of the dowel bars or 1/2 of the slab thickness. Clean the area by sand blasting and air blasting. The patch is then ready for concrete placement. See Figures A and B 5-694.922.

Between the initial milling and concrete placement, the Inspector must recheck the slab to insure that all unsound concrete is removed. Occasionally the removal operations cause some damage requiring additional removals of spalled areas.

The concrete mix design used is 3U18. Generally, there are three ways the concrete is mixed and all of these methods can achieve good concrete.

1. Continuous mixing concrete mobile - make sure that all concrete is out of the chute when production stops. Otherwise, when production starts again, the old concrete is re-tempered and the concrete will shrink excessively when it sets up.
2. Paddle mixer and bagged 3U18 concrete mix - the bagged mix must meet the requirements of Specification 3105.
3. Paddle mixer and virgin materials - normally the mix design is prorated to one or two bags of cement.

The patch area, that has been checked and cleaned, has bonding grout applied directly before concrete placement. The concrete is finished to grade, slope and texture. Grout is used to seal the edges, and then curing compound is applied.

**5-694.922 IMPORTANT POINTS OF PARTIAL DEPTH REPAIRS**

Partial depth repair is the most workmanship dependent operation that Mn/DOT does with respect to concrete.

Below are some of the very important points to follow for a successful repair.

- Sever misaligned dowel bars or those that have lost cross section. Coat dowel bars left in place with an approved form release agent. If the end of a dowel bar is exposed, attach a compressible material to allow movement.
- Maintain compression relief. No concrete shall extend below the dowels. Either sand or foam must extend below the bars to fill any void. In addition, either the green sawing or compression relief material must go to the depth of the dowels. Edge around all inserts.

- Re-establish all cracks and joints in the exact location as in the original pavement.
- Apply curing compound immediately after concrete placement otherwise shrinkage and de-bonding will occur. The following are a list of Type B Repairs.

#### Type B-1

Use for repairing spalled cracks greater than 2 m (6 ft).

#### Type B-2A

Use for shallow depth of 50 to 100 mm (2 to 4 in.) spot surface repairs that are less than 3 m<sup>2</sup> (30 ft<sup>2</sup>). The repair may be along a joint or crack, or at any location within a panel. This repair is also used when Repair Types B-1, B-2C, B-2D or B-3 exceed the 250 mm (10 in.) minimum dimension because of deteriorated or delaminated concrete. Extra width to accommodate the Contractor's equipment shall be at the Contractor's expense. See Figures C, D, E, and F 5-694.922 for examples of partially and completed Type B-2A repairs.

#### Type B-2B

This repair is similar to Repair Type B-2A except that the minimum area is 3 m<sup>2</sup> (30 ft<sup>2</sup>).

#### Type B-2C

Use for spalled concrete repair along a longitudinal edge of a panel. It has a minimum dimension of 2 m (6 ft.) along the edge and a maximum depth of T/2. If deterioration extends deeper than T/2, use a Type B-2D repair in addition to a Type B-2C repair.

#### Type B-2D

Use where deterioration along a longitudinal edge exceeds T/2 in depth. Generally, this deterioration will extend to the bottom of the pavement.

#### Type B-2E

For the ends of joints or cracks where the full-depth deterioration extends up to 450 mm (18 in.) from the end. Generally used in conjunction with a B-2A repair. See Figure F 5-694.922 for an example of a Type B-2E repair.

#### Type B-3

Use for spall repair along transverse joints. This repair may also be utilized to repair longitudinal joints, usually centerline joints that were formed with inserts. See Figures D 5-694.922 and F 5-694.922 for examples of partial and completed Type B-3 repairs.



**Figure A 5-694.922**



**Figure B 5-694.922**



**Figure C 5-694.922**



**Figure D 5-694.922**



**Figure E 5-694.922**



**Figure F 5-694.922**

**5-694.930 TYPE C REPAIRS - FULL-DEPTH REPAIR**

The letter C designates full-depth repairs. Type C repairs consist of full thickness removal of the concrete for a distance of 1 m (3.5 ft.). A Type CX repair is used in conjunction with Type C repair if the removal extends beyond the required 1 m (3.5 ft.) but less than 4 m (13 ft.) total when measured with the centerline. See Figure A 5-694.932 for a candidate for a Type C3-D and CX Repair.

**5-694.931 FULL-DEPTH PROCEDURES**

The removal area is defined with the 1 m (3.5 ft.) minimum in mind. The deteriorated area is removed by saw cutting either end and then lifting the slab out. It is recommended to remove the slab using pick holes and pins to reduce the possibility of spalling off the edge of the remaining concrete. Re-compact the base material to grade if disturbed. Tie bars or dowel bars are put on each end of the repair by drilling holes and securing the bars with an approved epoxy or non-shrink grout. Sometimes dowel baskets or additional steel is required for the repair. See Figure B 5-694.932 for a partially completed C-3D repair.

While dowel bars are grouted or epoxied into place, check them for tolerance. The tolerance is 3 mm (1/8 in.) with respect to both the pavement profile and centerline. Verify all drilled bars are secure before concrete is placed. Secure dowel baskets if they are used and tolerance the base.

The concrete mix designs used for Type C repairs are 3A32HE, 3U22, 3U27, or 3U28. The use of accelerators is acceptable if early opening times are required. The mix is produced at a ready-mix plant. The Contractor must meet surface tolerance according to Specification 2301, concrete paving. The concrete is struck off, floated, textured, and cured.

**5-694.932 IMPORTANT POINTS OF FULL-DEPTH REPAIRS**

The alignment of the dowel bars is extremely important to the success of full-depth repairs. Check to assure the epoxy or non-shrinking grout is fully set up and the dowels are checked for straightness before concrete is placed.

The other most important point is that a white linseed oil or resin based curing compound is placed immediately and properly after concrete is placed. The following is a list of Type C Repairs.

**Type C-1**

For "spot" full-depth repairs. The detail sheet lists a 2 m (6 ft.) maximum dimension along a joint. The minimum and maximum dimensions of these repairs should be 1 m x 1 m (3.5 ft. x 3.5 ft.) and 1 m x 2 m (3.5 ft. x 6 ft.) respectively. If the maximum dimension exceeds 2 m (6 ft.), it is recommended to use a C-3A, C-3AS, or C-3D. See Figure C 5-694.932 for an example of a Type C-1 repair.

**Type C-2**

Is intended to repair concrete pavement over utility trenches.

**Type C-3A**

Use for full-depth repair of transverse contraction joints. The holes for the dowel bars must be drilled straight such that the dowels are aligned to within 3 mm (1/8 in.) tolerance of both the pavement profile and centerline. A Type C-3D repair is recommended for most repairs of this type since it is doweled at both ends, helping to ensure that at least one of the ends allows for contraction and expansion.

**Type C-3AS**

Use for full-depth repair of transverse contraction joints. It differs from the Type C-3A repair in that a dowel basket is used for alignment of the dowels. A Type C-3D repair is recommended for most repairs of this type since it is doweled at both ends, helping to ensure that at least one of the ends allows for contraction and expansion.

**Type C-3B**

This repair is similar to Type C-3A except that it is an expansion joint, not contraction.

**Type C-3BS**

This repair is similar to Type C-3AS except that it is an expansion joint, not contraction.

**Type C-3D**

This is the preferred full-depth contraction joint repair. It is doweled at both ends to help assure the repair will allow contraction and expansion. See Figure D and E 5-694.932 for examples of Type C-3D repairs.

**Type C-4A**

Use for full-depth repair of "non-tied" longitudinal joints between adjacent lanes.

**Type C-4B**

Use for full-depth repair of "tied" longitudinal joints between adjacent lanes.

**Type C-4C**

Use for full-depth repair of the longitudinal edge of a lane. If the repair required is greater than 600 mm (2 ft.) a Type C-3D repair is recommended.



Figure A 5-694.932



Figure B 5-694.932

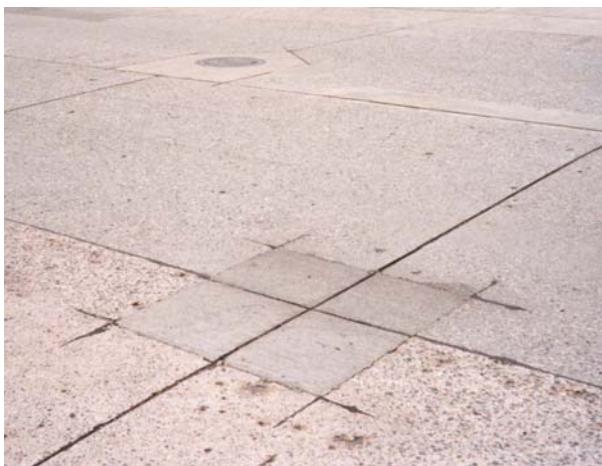


Figure C 5-694.932



Figure D 5-694.932



Figure E 5-694.932

**5-694.940 TYPE D REPAIRS - SLAB REPLACEMENT**

Any full-depth repair that is longer than 4 m (13 ft.) is a Type D repair. The procedures for this type of repair are the same as Type C repair. Possible concrete mixes used are 3A32, 3A32HE, 3U22, 3U27, 3U28, and 3A41. See Figure A 5-694.940 for a candidate Type D-2 repair.

A Type D repair is generally used for removal and replacement of one or more concrete pavement panels. It is also used if the length of full-depth repair within a panel exceeds 4 m (13 ft.) along centerline. The first 1 m (3.5 ft.) of a Type D repair is paid for as a Type C Repair. The remainder, 3 m (9.5 ft.) or more, is paid as a Type D repair.

**Note:** For repairs that require early opening times, a 3A32HE utilizing a Type E admixture has historically worked the best. A summary of mixes and their opening times is included in the Mn/DOT Repair Standards.

**5-694.941 IMPORTANT POINTS OF SLAB REPLACEMENT**

Often times a Type D repair exists in only one lane of a multi-lane slab. In many cases these pavements have 8.2 m (27 ft.) joint spacing. It is recommended that a joint be established near the middle of the repair to prevent a random mid-panel crack. If the 8.2 m (27 ft.) panel has a mid-panel crack, establish the joint to match where the mid-panel crack exists. The following is a list of Type D and other miscellaneous repairs.

**Type D-1**

For full-depth replacement of panels in adjacent lanes. It is also used for full-depth, partial panel repair, if the length exceeds 4 m (13 ft.) along centerline. See Figure A 5-694.941 for a Type D-1 repair.

**Type D-2**

For full-depth replacement of panels in single lanes. It is also used for full-depth, partial panel repair, if the length exceeds 4 m (13 ft.) along centerline. See Figure B 5-694.941 for a Type D-2 repair.

**Figure A 5-694.940**



**Figure A 5-694.941**



**Figure B 5-694.941**

## **5-694.945 OTHER TYPES OF SPECIALIZED REPAIRS**

Type CRCP repair is rarely used. There is a small amount of continuous reinforced concrete pavement in Minnesota; therefore, Repair Standards include repair techniques for CRCP pavement.

### **CRCP-1**

Generally, this repair is intended to repair concrete pavement over utility trenches.

### **CRCP-2**

Used for full-depth repairs on continuously reinforced concrete pavement (CRCP) that utilizes a wide flange beam for an expansion device.

### **Relief Cut**

The relief cut is not a repair. It is used at the discretion of the Engineer to prevent a pavement blowup during full-depth repair operations. The relief cut consists of making a temporary 100 mm (4 in.) wide full-depth cut prior to making a full-depth repair in an adjacent tied concrete lane. The relief cut portion of the joint is then repaired after completion of the adjacent full-depth repair.

**5-694.950 CONCRETE TEXTURE-PLANING**

To provide a smooth ride for the user, the Engineer may require the Contractor to texture-plane a concrete pavement after concrete pavement repairs or as a separate action to improve the ride. Texture-planing is commonly referred to as diamond grinding.

This work consists of planing and texturing the surface of the existing concrete pavement in the longitudinal direction as directed by the Engineer. The intent of this Specification is to improve skid resistance, correct surface defects and promote drainage. Remove existing joint seals prior to or in conjunction with the texture planing operation; however, tolerances for joint sealing are measured from the resulting planed surface.

Make all concrete repairs to the existing concrete pavement prior to beginning the concrete texture-planing operation. Texture-plane all repairs, except Type D repairs in excess of 9 m (30 ft.). Those Type D repairs in excess of 9 m (30 ft.) shall have a 5 m (15 ft.) minimum texture-planed run out at each end to eliminate bumps.

The entire surface area of the identified pavement is planed to a uniform texture. The surface shall have a finished texture with grooves between 2.5 mm (0.097 in.) and 3.3 mm (0.130 in.), and 2.03 mm (0.080 in.) and 2.92 mm (0.115 in.) apart. The Contractor shall adjust the width of kerf (space between the grooves) to maximize skid resistance with the grooves not less than 0.787 mm (0.031 in.) or more than 2.92 mm (0.115 in.) in depth. The Contractor shall provide texturing for at least 98% of any selected 0.6 m x 30 m (2 ft. x 100 ft.) longitudinal area of pavement.

Check the Mn/DOT Office of Technical Support Website for Texture-Planing Special Provisions with and without incentives for ride quality. A certified California Profilograph or Lightweight Inertial Profiler is required to check the smoothness. When using Incentive/Disincentive Specifications, the Engineer may choose to exempt large dips and bumps, to avoid excessive planing, and feather in and out of these areas.

See Figure A 5-694.950 for an example of planing equipment. See Figure B 5-694.950 for an example of a concrete pavement before and after texture-planing.



**Figure A 5-694.950**



**Figure B 5-694.950**

**5-694.960 DOWEL BAR RETROFIT**

The dowel bar retrofit repair is used for establishing load transfer at cracks or joints. This repair is considered when the concrete is structurally sound and the main deficiency of the pavement is load transfer. If this repair is considered and the pavement is faulted, texture-planing the pavement is also recommended. Contact the Mn/DOT Concrete Engineering Unit for further details and current specifications.

The Contractor installs slots in the pavement, places dowels in the slots, then places patching material in the slots and around the dowel bars. Figure A 5-694.960 illustrates sawing the slots for the repair. Figure B 5-694.960 illustrates a dowel bar retrofit repair prepared for placing patching material. Note how caulk prevents the intrusion of paste into the joints. Figure C 5-694.960 illustrates a repair where the patching material was just placed. Texture-planing as shown in Figure D 5-694.960 finishes off the retrofit dowel repair. See Special Provisions for details regarding this procedure.



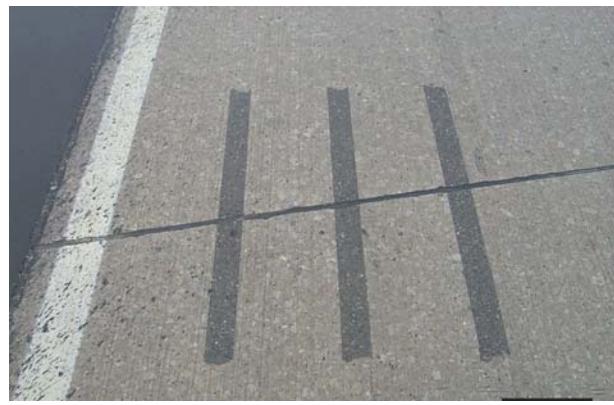
**Figure A 5-694.960**



**Figure B 5-694.960**



**Figure C 5-694.960**



**Figure D 5-694.960**