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Division 02 – Technical Specifications

Division 02 – Technical Specifications shall be the Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction, 2017 Edition, except as modified in this document.

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Appendix A – ACPA Technical Bulletin “Guidelines for Partial-Depth Repair”

Division 02 – General Provisions

PART 1: General

Description

A. Work described elsewhere in the technical specifications, contract drawings or Part I of the contract documents shall be done in accordance with the Colorado Department of Transportation (CDOT) **2017 Standard Specifications for Road and Bridge Construction** (except as noted below) and the latest edition of the **Colorado Standard Plans (M&S Standards).**

B. The Colorado Department of Transportation General Provisions consisting of Section 100 through 109 of the above referenced "Standard Specifications" and are NOT applicable to this Contract and are hereby deleted, except were specifically added in, these project Special Provisions. In place of the deleted, the City and County of Denver's General Provisions, General Conditions, Special Conditions and Technical Specifications are attached to and made part of the contract.

The following sections shall apply as noted:

1. Section 101 Definitions and Terms
2. Section 105 Control of Work with the following exceptions:
    a. If there are any conflicts with City and County of Denver's General Provisions, General Conditions, Special Conditions or Technical Specifications and this section, those documents will take precedence.
    b. Any reference to incentives shall be disregarded. NO incentives will be paid on this project. References to disincentives, corrective work or removal and rejection of work and/or materials shall apply.
    c. Section 105.21 Acceptance shall not apply.
    d. Section 105.22 through 105.24 shall not apply.
3. Section 106 Control of Material
4. Section 109.01 Measurement of Quantities

Part 2: References

1. All references to "CDOT or the Department" shall be changed to "City and County of Denver" unless otherwise noted.
2. All references to the CDOT Project Engineer and CDOT Regional Transportation Director shall mean DEN Project Manager and DEN Manager of Construction.
3. Any and all reference to incentives or positive pay factors within any documents pertaining to this contract shall not apply. NO incentives or increase pay factors will be paid on this project. References to disincentives, negative pay factors, corrective work or removal and rejection of work and/or materials shall apply.

Part 3: Applicable Publications

Copies of the CDOT Standard Specifications for Road and Bridge Construction, Colorado Standard Plans (M&S) Standards, and the Colorado Procedures Field Materials Manual are available for purchase at:

Colorado Department of Transportation
Bid Plans Room
4201 East Arkansas Avenue
Denver, CO 80222

End of Section

Division 02 – Project Special Provisions

Revision of Section 104
Lane Rental Fee

Lane Rental Fee. The Contractor shall pay an hourly lane-mile rental fee for lane closures on Peña Boulevard that are in place outside of hours approved by DEN through an approved Shutdown Request. At least one lane of Peña Boulevard, in each direction, shall remain open at all times during nightly lanes closures.

The deduction will be based on the applicable rate for any and all closures, whether work is performed or not. This deduction will be reflected in each progress payment.

The lane-mile rental fee for closures on Peña Boulevard shall be $6,000.00 per lane-mile hour.

Lane-miles of closure will be measured for each closed 12-foot lane, or portion thereof, times the length of closure in miles. The length will be measured to the nearest 0.1 mile, rounded up; from the beginning of the taper to the last traffic control device that obstructs the lane.

Lane-mile hours of closure will be measured by the number of lane miles multiplied by the duration in hours of the closure. The duration begins when the closure set up begins, and ends when all traffic control devices, excluding signs, are removed from the roadway. The duration will be measured in 15 minute increments or any portion thereof.

A lane is considered closed when the number of available lanes is reduced from the number available prior to the work. Acceleration lanes, deceleration lanes, and shoulders will not be included in the calculations to determine lane-mile hours.

Lane closures shall be documented by the Traffic Control Supervisor (TCS's) diary each day that lane closure is in use. The diary shall be signed by the TCS and the Contractor's representative. A copy of the day's diary shall be given to the DEN Project Manager at the end of each work day on which a lane closure is used.

End of Section

Revision of Section 105
Violation of Working Time Limitation

Section 105 of the Standard Specifications is hereby revised for this project as follows:

Subsection 105.03 shall include the following:

If there is a violation of the working time limitations for traffic control as set forth in the special provisions, a written notice to stop work will be imposed on the Contractor at the start of the next working day. Work shall not resume until the Contractor assures the Engineer, in writing, that there will not be a reoccurrence of the working time violation. If more violations take place, the Engineer will notify the Contractor in writing that there will be a price reduction charge for each incident in accordance with this specification. This incident price reduction charge will be deducted from any money due the Contractor. This price reduction will not be considered a penalty but will be a price reduction for failure to perform traffic control in compliance with the Contract.

An incident is any violation up to 30 minutes in duration. Each 30-minute or increment thereof will be considered as an incident. A price reduction will be assessed for each successive or cumulative 30-minute period in violation of the working time limitations, as determined by the Engineer. The price reduction for each incident will increase at a progressive rate starting with $150 for the second incident and increasing to $1200 for the fifth and subsequent incidents in accordance with the following schedule. A 15-minute grace period will be allowed at the beginning of the second incident on the project before the price reduction is applied. This 15-minute grace period applies only to the second incident.

The number of incident charges will be cumulative throughout the duration of the Contract.

Price Reduction Schedule

Incident	Incident Rate	Total Price Reduction
1st	Notice to Stop Work	----
2nd	$150	$150
3rd	$300	$450
4th	$600	$1,050
5th	$1,200	$2,250
6th	$1,200	$3,450
Etc.	$1,200	$4,650
	Etc.	Etc.

End of Section

Revision of Section 202
Removal and Disposal of Concrete and Asphalt

Section 202 of the CDOT Standard Specifications is hereby revised for this project as follows:

Subsection 202.01 shall include the following:

Concrete and asphalt may be disposed of at the DEN South Recycle Yard or at Denver Arapahoe Disposal Site (DADS) as outlined in the following paragraphs. All other material or waste shall be disposed of at DADS in accordance with Division 01 Section 015719 Part C executive order No. 115.

DEN South Recycle Yard
Asphalt millings, concrete pavement, and concrete slurry may be applied or disposed at the DEN South Recycle yard at the discretion of the DEN Project Manager. All disposals shall be coordinated with DEN a minimum of 48 hours in advance.

All material shall be free of debris, including steel reinforcement, and shall be sized to 2-foot minus. DEN reserves the right to reject material that is deemed unclean or unsuitable. DEN may request that material be removed from the yard if deemed unclean or unsuitable after being dumped at the DEN South Recycle yard at no extra cost.

DADS
The Contractor may also dispose of material at the DADS facility in accordance with Division 01 Section 015719 Part C executive order No. 115. DADS is located at 3500 E Gun Club Rd. in Aurora. Use of DADS shall be coordinated with the DEN Project Manager 24 hours prior to disposal to obtain DEN disposal tickets.

Subsection 202.12 shall include the following**:**

Payment will be made under:

Pay Item		**Pay Unit**
202-00210	Removal of Concrete Pavement	Square Yard
202-00220	Removal of Asphalt Mat	Square yard

Unless otherwise specified in the Contract, the removal, disposal, and sizing of items or their use in other locations on the project will not be measured and paid for separately, but shall be included in the work.

End of Section

Revision of Section 202
Removal of Expansion Device

Section 202 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work shall consist of removing existing bridge expansion devices and existing retrofit of expansion devices at locations shown on the plans in accordance with the applicable portions of Section 202 of the Standard Specifications or as amended by these Special Provisions and in conformity with the plans or as directed. Bridge expansion devices shall include strip seal expansion devices, compression seal joints, asphaltic joints, poured joints and any other type of joint at the location where the bridge approach slabs meet the sleeper slabs and/or the concrete pavement at all bridges and at the back face of the south abutment at bridges D-31-PB-220 and D-31-PB-230.

CONSTRUCTION REQUIREMENTS

Removal operations shall be coordinated with the stage construction as shown on the plans, indicated in the Contract, or as directed by the Engineer.

At least 10 days before beginning removal, the Contractor shall submit to the Engineer details of the removal operations showing the means, methods, sequence of removal, tools, and equipment to be used. All removal operations, methods and equipment must be approved by the Engineer before the work begins.

The existing concrete shall be removed as shown on the plans or as directed by the Engineer. The Contractor shall saw cut along the removal limits prior to removal. Removal operations shall not occur prior to approval of the Engineer. The sawing of concrete shall be done to a true line, with a vertical face, unless otherwise specified and shall be performed with a track mounted blade. Feathered edges will not be acceptable. The approximate depth of the saw cut shall be ¾-inch minimum, unless otherwise noted on the plans.

The Contractor shall take all steps necessary to minimize spalling on the face of the existing concrete adjacent to the removal boundaries and to avoid damage to the existing bridge deck and approach slabs. Removals adjacent to the removal boundaries shall not use pneumatic hammers heavier than nominal 30-pound class. Hand tools such as hammers and chisels shall be used for removal of final particles of loose, unbonded concrete. Any damage caused by the Contractor to any portion of the structure not intended for repair shall be repaired in kind by the Contractor at the Contractor's expense.

The Contractor shall take all steps necessary to prevent cutting or otherwise damaging reinforcing steel intended to remain in place. Any reinforcing bars damaged by the Contractor's operation shall be repaired or replaced at the Contractor's expense using means and methods approved by the Engineer and with no allowance for contract time extension.

The Contractor is responsible for the disposal of all removed material and debris. Disposal shall not be paid for separately but shall be included in the work.

METHOD OF MEASUREMENT

Expansion devices removed will be measured by the linear foot between faces of curbs and parallel to the expansion joint. Saw cutting will not be measured separately

BASIS OF PAYMENT

Payment shall be made at the contract unit price per linear foot for the accepted quantity removed.

Payment will be made under:

Pay Item	Pay Unit
Removal of Expansion Device	Linear Foot

Payment will be full compensation for all labor, materials, tools, equipment and incidentals necessary to complete the item including saw cutting, removal of concrete as designated in the plans, reinforcing steel not designated to remain in the plans, straightening existing reinforcing steel to remain, removal of expansion device and sandblasting or hand cleaning including epoxy coating repair, and disposal of removed materials.

End of Section

Revision of Section 202
Removal of Portions of Present Structure (Class 2)

Section 202 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of saw cutting, removal and disposal of existing deteriorated approach slab, sleeper stem, and pavement concrete. Removal operations shall be conducted so that public traffic is protected, and so that there will be the least interference with public traffic using the structure.

The locations and limits of removal shall be as determined by the Engineer.

CONSTRUCTION REQUIREMENTS

a) General:

At least 10 days before start of work, the Contractor shall submit to the Engineer details of the removal operations showing the methods and sequence of removal and equipment and tools to be used. The Contractor's submittal shall also include proposed methods used to: determine the locations of deteriorating concrete, prohibit debris from falling to the ground below the structure, and protect public traffic using the structure, and adjacent to the structure, from airborne debris generated by the removal operations.

All methods and equipment used to accomplish this item shall be approved by the Engineer.

Prior to removal of concrete, the Contractor shall sound the area within two-feet of the expansion joint for delamination in accordance with ASTM D4580, Procedure B Chain Drag. The Contractor shall mark the areas of deteriorated concrete to be removed as directed by the Engineer. The Contractor will not be compensated for removal areas or patching areas not designated for removal by the Engineer.

Sawing of concrete shall be done to a true line, with a vertical face, unless otherwise specified. The approximate depth of a saw cut in concrete shall be 3/4 inch, unless otherwise noted in the plans.

The Contractor shall remove and repair only the amount of work that can be completed and opened to traffic within the designated lane closure times as specified in the Traffic Control Plan.

The Contractor shall take all steps necessary to prevent cutting or otherwise damaging reinforcing steel, including any vertical stirrups, and/or structural steel including expansion device anchors and armor projecting into the approach slab and sleeper stem. All bars or expansion device elements damaged by the Contractor's operations shall be repaired or replaced at the Contractor's expense.

Following sandblasting, the condition of all exposed reinforcing bars shall be inspected by the Engineer. If, in the opinion of the Engineer, the loss of original cross sectional area of the bar due deterioration is 25 percent or more, the Contractor shall add additional bars as approved by the Engineer. New added bars shall be lap spliced as shown in the plans. Payment for the new reinforcement steel shall be made in accordance with Section 602. If the required lap splice length cannot be utilized, a mechanical splice shall be used. The mechanical splice shall develop at least 125 percent of the specified yield strength of the bar. The Mechanical splice shall be per CDOT list of approved products. All minimum clearances shall be maintained. Payment for the Mechanical splice will be as the weight of reinforcing steel for the designated lap splice for that bar size. As an alternative, the Contractor may remove additional sound concrete to achieve the required lap length.

Payment for additional removals and repairs will be based on the unit price for the appropriate class of removal and repair method. Removal and repairs beyond the minimim required lap length will not be paid for.

All reinforcing steel shall be secured to adjacent bars or to the bridge deck as provided in subsection 602.

All areas of the prepared surface contaminated by oil or other materials detrimental to good bond shall be thoroughly cleaned by a method approved by the Engineer. Such cleaning work will not be paid for separately, but shall be included in the work.

b) Class 2:

Removal of Portions of Present Structure (Class 2) shall consist of removing existing concrete within the limits shown on the plans, or as designated by the Engineer. Class 2 removal shall begin at the surface of the existing concrete and extend to sound concrete, but not less than 1 inch below the top transverse and longitudinal reinforcing steel.

Wherever solid bond between existing concrete and reinforcing steel is lacking, or where more than half of the diameter of the reinforcing bars is exposed by removal of concrete, the concrete adjacent to the bar shall be removed a minimum of one inch below and around the bar to permit new construction to bond to the entire periphery of the bar. Pneumatic hammers heavier than nominal 30-pound class shall not be used in removing concrete from below and around reinforcing steel**.** Care shall be taken so as not to fracture sound concrete in the bottom half of the bridge deck.

Removal may be performed by power chipping or hand tools in accordance with these specifications or as otherwise approved by the Engineer.

c) Surface Preparation Equipment

Sandblasting equipment shall be capable of removing rust scale from reinforcing bars and removing small chips of concrete partially loosened or fractured by the scarifying or chipping operations.

Pneumatic hammers heavier than nominal 90-pound class will not be permitted. Pneumatic hammers and chipping tools shall not be operated at an angle exceeding 60° relative to the surface of the slab. Such tools may be started in the vertical position but must be immediately tilted to 60° operating angle.

Hand tools such as hammers and chisels shall be provided for removal of final particles of loose, unbonded concrete. Only short, one-handed hammers with a maximum head weight of 5 pounds will be allowed. Hydraulic demolition may be utilized with approval of Engineer.

METHOD OF MEASUREMENT

Removal of Portions of Present Structure will be measured by the actual area of square yards, completed to the required depth, and accepted.

BASIS OF PAYMENT

Planned deck rehabilitation quantities are approximate. The actual accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Removal of Portions of Present Structure (Class 2)	Square Yard

Payment for Removal of Portions of Present Structure (Class 2) will be full compensation for all labor, equipment, and material required to perform the neat line removals to the required depth, methods to prohibit debris from falling from the structure, and methods to protect the public traffic using the structure, or adjacent to the structure, from airborne debris.

Saw cutting will not be paid for separately, but shall be included in the work.

Sounding will not be paid for separately, but shall be included in the work.

Sandblasting will not be paid for separately, but shall be included in the work.

End of Section

Revision of Section 202
Sandblasting

Section 202 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

Sandblasting shall consist of cleaning exposed non-epoxy reinforcing steel designated to remain in place and roughening the surface and removing all fractured particles from the entire existing concrete surface against which new concrete is to be placed.

CONSTRUCTION REQUIREMENTS

(a) General

Following the removal of adjacent concrete, all exposed non-epoxy reinforcing steel designated to remain in place shall be cleaned to sound steel by sandblasting. Sound steel is defined as free of oil, dirt, concrete fragments, or laitance, loose rust scale, and other coatings of any character that would destroy or inhibit the bond with the new concrete. Epoxy-coated steel shall not be sandblasted.

Sandblasting equipment shall be capable of removing rust scale and concrete fragments or laitance from reinforcing steel, roughening existing surface, and removing all fractured particles from the existing concrete surface.

Rust that may form on the reinforcing steel within seven calendar days following the accepted sandblasting, will not be cause for rejection of the steel.

When acceptable reinforcing steel is exposed to the elements for more than seven calendar days prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect the steel from contamination or corrosion. Reinforcing steel contaminated as a result of the Contractor's failure to provide adequate protection as stipulated herein, shall be re-sandblasted at the Contractor's expense with no allowance for contract time extension.

(b) Equipment

Sandblasting equipment shall be capable of removing rust scale and concrete fragments or laitance from reinforcing steel, roughening existing surface, and removing all fractured particles from the existing concrete surface.

BASIS OF PAYMENT

Sandblasting, including labor, materials, tools, equipment and incidentals, will not be measured and paid for separately but shall be included in the work.

End of Section

Revision of Section 412
Diamond Ground Surface Finish

Section 412 of the Standard Specifications is hereby revised for this project as follows:

Subsection 412.01 shall include the following:

This work consists of uniformly grinding the surface of the existing concrete pavement to the lines, grades, and limits shown on the Plans or as directed by the Engineer.

This work includes removing the existing joint sealant, sawing, cleaning, and resealing existing concrete pavement joints and routing and sealing of random cracks in the concrete pavement in accordance with this specification or as directed by the Engineer.

A hardness of approximately 7 is anticipated for the existing concrete pavement based on the Moh's hardness scale. For bidding purposes, the Contractor shall be responsible for verifying the hardness of the existing concrete pavement.

Subsection 412.12 shall include the following:

(e) *Diamond Ground Surface Finish.* The Contractor shall diamond grind the concrete travel lane pavement surface within designated limits as shown on the Plans or as directed by the Engineer. The minimum depth of grinding shall be determined by the Contractor to produce a diamond ground surface finish that covers a minimum of 95% of the concrete travel lane pavement surface finish or as directed by the Engineer. The finished grinding surface finish shall maintain the planned cross slope of the roadway in the travel lanes as well as those areas on the shoulder or painted island which are ground. Longitudinal tining will not be required in areas that are designated to have a diamond ground surface.

The Contractor shall profile each travel lane, any deceleration lane, acceleration lane, or turn lane, one (1) week prior to starting any grinding and submit the information to the Engineer immediately at the completion of the work.

The Contractor shall submit a detailed grinding plan for accomplishing the grinding to the Engineer for approval prior to beginning work on the Project. The grinding plan shall include a sequence for grinding which produces the desired surface ride qualities with a minimum grinding depth throughout the Project. The Engineer's approval shall not relieve the Contractor of his responsibility of producing work in conformity with the Contract. The Contractor's grinding plan shall address grinding around manhole covers, bridge expansion joints, and pavement edge drains, and shall include a plan for slurry disposal.

Grinding shall be performed using diamond blades mounted on a self-propelled machine designed for grinding concrete pavement. The equipment shall be at a minimum 35,000 pounds, including the grinding head, and of a size that will grind a strip at least 3 feet wide. The effective wheel base of the machine shall be at least 12 feet. The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface, leaving the surface in a clean, near-dry condition. Grinding equipment that causes raveling, aggregate fractures or disturbance to the joints shall not be permitted. The equipment shall be maintained to ensure it is in proper working order, including the roundness of the match and depth control wheels. Any wheels found to be out of round shall be immediately replaced.

The entire surface width of the travel lane concrete pavement and all turn lanes shall be ground. Grinding shall begin and end at lines normal to the pavement centerline. All grinding shall be

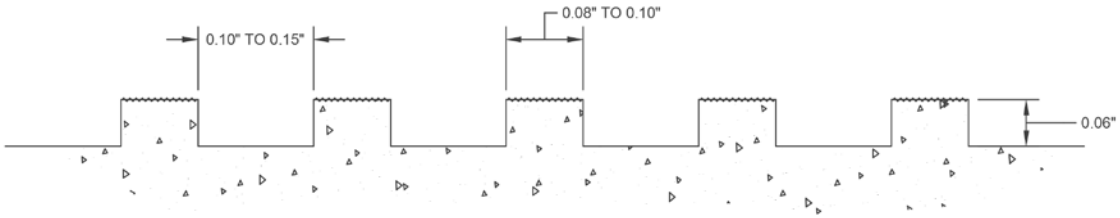
parallel to the longitudinal joints and performed in the longitudinal direction. Adjacent passes shall be overlapped a maximum of 2 inches. Ground surfaces shall be neat rectangular areas with a uniform surface appearance. The diamond grinding shall be tapered to a zero depth in a single full width pass from the shoulder into the drive lane, and from the drive lane into the edge of the painted or raised island.

The diamond grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaces. Any ridges on the outside edge next to the shoulder/bike lane or auxiliary lanes greater than 3/16 inch high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation.

Ground pavement surfaces shall have a skid resistant texture consisting of grooves between 0.10 and 0.15 inch wide, spaced 0.08 to 0.10 inch apart. The depth of the grooves shall be approximately 0.06 inch below the peaks of the adjacent ridges, as shown in Figure 412-1. Removal of slurry and residue, including joint sealant, resulting from the grinding operation shall be continuous and immediate, and pavement shall be left in a clean condition. Grinding slurry and residue shall be disposed of in accordance with Section 250 and Division 01 Specifications. In no case shall the grinding slurry be dumped on the Project, or allowed to enter any stream. It shall be the Contractor's responsibility to locate a suitable disposal site for the grinding slurry and residue.

No adverse drainage conditions shall be caused by the grinding operations.

Figure 412-1
Diamond Ground Surface Texture Detail



Subsection 412.13 shall include the following:

(d) *Resealing Existing Joints and Sealing or Resealing Random Cracks.* The existing longitudinal and transverse joints are approximately 3/8 inch wide, and may need to be widened by 1/6 inch or less in order to facilitate cleaning. There may also be existing joints that are wider than 3/8 inch. Any longitudinal or transverse joint wider than 3/8 inch shall be paid for at the same unit price as 3/8 inch wide joints.

All joints and random cracks shall be sawed or routed to the widths and depths as directed by the Engineer. Sawcutting shall be done with a power cut-off saw equipped with diamond blades. Any damage to the concrete pavement, such as spalling or overcutting, shall be repaired by the Contractor, as directed by the Engineer, and at the Contractor's expense.

The Contractor shall thoroughly clean each sawed joint, and sawed or routed random crack, and the adjacent pavement surface, immediately after sawcutting.

Old joint sealant and water generated from this operation and other material resulting from sawing and sealing of concrete joints and cracks shall be collected by the Contractor and disposed of in accordance with Section 250 and Division 01 Specifications. Collection shall be

continuous and immediate and the pavement shall be left in a clean and dry condition before opening any section of roadway to traffic. This shall be accomplished by sweeping the entire area to prevent dust tracking to adjacent lanes or vehicles.

The backer rod shall be closed cell polyethylene foam rod. The rod diameter should be at least 25% greater than the width of the joint, so that it fits firmly in the joint. The backer rod shall be chemically and physically compatible with the joint sealant material, so as to not act as a bond breaker.

An approved hot applied joint sealant shall be used for any joints or cracks that are greater than one (1) inch wide. An approved silicone joint sealant shall be used on joints or cracks that are less than one (1) inch wide. The hot applied joint sealant and silicone joint sealant shall conform to Section 702.06 and Section 705.01, respectively.

Prior to placing joint sealant, the sawed joints and random cracks shall be sandblasted and thoroughly cleaned with oil-free compressed air. The sawed joints and random cracks shall be completely free of dirt, dust, moisture, or other foreign materials that might prevent bonding of the joint sealant material. It may be necessary to use a heat lance to remove moisture and dirt from joints and cracks prior to installation. No joint sealing will be allowed until the prepared sawed joints and random cracks have been inspected and approved by the Engineer.

The joint sealant material shall be applied and tooled in strict conformance with the manufacturer's recommended procedures and specifications. The sealant shall be placed so that its surface is 1/4 inch below the adjacent surface. Traffic shall be kept off of the freshly sealed cracks until the sealant has cured.

Joint sealing shall be accomplished only when the pavement is dry, the ambient and pavement temperature is 50 degrees Fahrenheit or higher, and the forecasted weather conditions are dry.

The Contractor is responsible for providing a one-year warranty (beginning on the date established with the Certificate of Final Acceptance) for the work performed under this contract. If any cracks open or if any of the material is removed from cracks due to traffic weathering, or any other reason, the Contractor shall reseal cracks with material, equipment, labor, and traffic control in accordance with these contract specifications within sixty (60) calendar days of notification.

The Contract must submit certificates of compliance with each shipment of material to be used. In addition, the City may contract with an independent testing lab to verify compliance with material specifications. Initial testing costs will be paid by the City, but costs of additional testing due to failure of material to meet specifications will be the responsibility of the Contractor. Shipments of material determined to not meet specifications will not be paid for whether they are installed or not.

Subsection 412.17 shall include the following:

The Contractor shall perform Smoothness Quality Control (SQC) testing. SQC testing shall be performed using the Contractor's Inertial Profiler, in accordance with the manufacturer's recommendations. The Contractor's Profiler shall be a dual wheel path high speed profiler and shall be certified according to CP 78. The Contractor shall clear the lanes to be tested of all debris before profiling. The profile of the roadway surface shall be taken in the intended direction of travel. The left and right wheel paths shall be profiled simultaneously. The entire length of each travel lane, from the beginning to the end of each travel lane of the Project, shall be profiled.

The Concrete pavement smoothness for this Project shall meet an HRI of ≤ 150 in/mile without exceeding a 1/2 inch maximum grinding depth. If the concrete pavement smoothness cannot meet an HRI of ≤ 150 in/mile without exceeding a 1/2 inch maximum grinding depth, then the pavement smoothness shall meet an HRI Percent Improvement of 50% or greater for each 0.05 mile segment per travel lane (excluding lanes less than 100-feet). If the concrete roadway smoothness is already an HRI of ≤ 150 in/mile then the Contractor shall be required to meet an HRI ≤ 80 in/mile without exceeding a ½ inch maximum grinding depth.

The pavement surface after diamond grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 3/16 inch in 10 feet when measured with a 10 foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

All traffic control costs associated with the SQC testing shall not be measured and paid for separately but shall be included in all other items of work.

Testing Procedure. The Contractor shall lay out a distance calibration site. The distance calibration site shall be located no more than five (5) miles from the Project limits. The distance calibration site shall be 1,056 feet long and shall be on a relatively flat, straight section of pavement as approved by the Engineer. The site shall have a speed limit equal to the Project's highest speed limit that allows for the HSP to operate uninterrupted. The limits of the site shall be clearly marked and the distance shall be measured to an accuracy of +/- 3 inches. The Contractor shall provide in writing the site location to the Engineer. The cost of the distance calibration site will not be measured and paid for separately, but shall be included in the work. The Contractor shall submit a Method for Handling Traffic (MHT) to the Engineer for approval at least five (5) days in advance of testing. The MHT shall detail the methods for traffic control that will allow for continuous non-stop profiling of each lane to be profiled at a minimum speed of 15 mph. The Contractor shall provide the traffic control in accordance with the approved MHT.

The concrete shoulder, bike lanes, or painted medians will not be profiled. All acceleration lanes, deceleration lanes, or turn lanes longer than 100 linear feet shall be included. A sufficient distance shall be deleted from the profile to allow the profiler to obtain the testing speed plus a 300 foot distance to stop and start when required.

The Contractor shall notify the Engineer in writing of his intention to perform SQC testing. This notification shall be at least five (5) working days in advance of any work. This includes but is not limited to the following work: manhole adjustment, valve box adjustments, curb and gutter repair, milling, planning, or patching.

The Engineer shall mark the profiling limits and excluded areas. The markings shall be located in a location that will not be disturbed, so that the section starts and stops locations will be identical for the initial and final pavement surface. The Engineer may determine that it is necessary to re-profile a lane.

Subsection 412.24 shall include the following:

Payment will be made under:

Pay Item		Pay Unit
412-10010	Diamond Ground Surface Finish	Square Yard
412-14000	Sawing and Sealing Concrete Pavement Joints	Linear Foot

Diamond ground surface finish shall be measured by the square yard of pavement surface ground, excluding overlaps. Resealing of transverse or longitudinal joints, and sealing or resealing of random cracks will be measured by the linear foot of sawing and sealing of pavement joints. Payment will be

considered full compensation for all labor, materials, tools, equipment, and incidentals necessary for completing the work.

Disposal of grinding slurry, including joint sealant material, will not be paid for separately, but shall be included in the work.

End of Section

Revision of Section 412
Partial Depth Concrete Pavement Repair

Section 412 of the Standard Specifications is hereby revised for this project as follows:

1.01 Description

Subsection 412.01 shall include the following:

A. This work includes repairing spalled or delaminated concrete pavement as described in the American Concrete Pavement Association Technical Bulletin "Guidelines For Partial-Depth Repair" and in accordance with this specification and the details shown on the plans.

Subsection 412.02 shall include the following:

B. The materials used shall be those as described in the American Concrete Pavement Association Technical Bulletin "Guidelines For Partial-Depth Repair" and in accordance with this specification and the details shown on the plans.

Subsection 412.16 shall include the following:

C. The construction requirements shall be those as described in the American Concrete Pavement Association Technical Bulletin "Guidelines For Partial-Depth Repair" and in accordance with this specification and the details shown on the plans.

Subsection 412.23 shall include the following:

D. Partial Depth Repair of concrete pavement will be measured for payment by the square foot of pavement repaired with a partial depth repair which conforms to the American Concrete Pavement Association Technical Bulletin "Guidelines For Partial-Depth Repair and in accordance with this specification and the details shown on the plans.

Subsection 412.24 shall include the following:

E. The accepted quantities of concrete pavement partial-depth repair will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. The price per square foot of concrete pavement partial-depth repair shall be compensation for furnishing and placing all materials according to the American Concrete Pavement Association Technical Bulletin "Guidelines For Partial-Depth Repair" and in accordance with this specification and the details shown on the plans.

Payment will be made under:

Pay Item		Pay Unit
412-05000	Partial Depth Repair of Concrete Pavement	Square Foot

End of Section

Revision of Section 518
Bridge Compression Joint Sealer

Section 518 of the Standard Specifications is hereby revised for this project to include the following:

Subsection 518.01 shall include the following:

This work shall consist of removing and replacing existing elastomeric compression seals in existing pavement and bridge approach slab joints, as well as installing new elastomeric compression seals in new pavement and bridge approach slab joints, both in accordance with these specifications and in conformity with the details shown on the plans or as directed by the Engineer. This work shall also consist of preparing existing or new concrete pavement openings for the compression seal installation.

Subsection 518.04 shall include the following:

The existing expansion device consists of a strip seal expansion device, elastomeric compression seal, asphaltic joint, or poured joint. The replacement expansion device consists of a new compression seal installed in the rehabilitated pavement gap.

Compression seals shall meet the requirements of ASTM D3542.
Adhesive lubricant shall meet the requirements of ASTM D4070.

The installed compression seal shall seal the pavement joint as indicated on the plans and prevent water from seeping through to the sleeper slab or surface below.

The compression seal shall consist of a preformed polychloroprene compression seal and shall have a rated movement of 2.9 inches. Acceptable manufacturers and models include the following or an approved equal:

DS Brown
Model: Delastic - CA-6000
419-257-3561
www.dsbrown.com

Watson Bowman
Model: Wabo – WA-600
800-677-4922
www.wbacorp.com

Erie Metal Specialties
Model: BR-600
716-542-3991
www.eriemetal.com

Subsection 518.09 shall include the following:

The installation of the new compression seals shall conform to the staged construction plan shown on the traffic control plans unless otherwise directed by the Engineer.

The methods and equipment used to prepare the existing surface and install the new compression seal shall be approved by the Engineer. The Contractor shall take all steps necessary to avoid damage to all existing concrete. Any concrete damaged by the Contractor's operation shall be repaired or replaced at the Contractor's expense with no allowance for contract time extension.

As part of the working drawing submittal, at least 10 days prior to delivering the compression seal to the job site, the Contractor shall submit two copies of the manufacturer's written instructions for pertinent materials and installation data of the bridge compression seal to the Engineer for information.

(a) *Surface Preparation:*

The vertical joint opening concrete surfaces shall be sawcut or formed as required to achieve the appropriate width and depth as shown in the plans.

For joint openings that are formed, the joint opening blockout width shall be within 1/16 inch of the width shown in the Temperature Table or designated dimensions shown in the plans. The blockout width shall correspond to the appropriate ambient temperature at the time of concrete placement.

Finished concrete joint surfaces shall be cleaned by use of sandblasting, or another method approved by the Engineer, until all unsound materials, adhesive, and contaminants are removed. The joint opening surfaces shall be smooth, true, and vertical. The opening faces shall be parallel and the opening width shall not vary by more than 1/16 inch along the length of the joint. All vertical surface imperfections, including saw blade gouges, greater than 1/16 inch shall be patched with CDOT approved non-shrink epoxy grout or ground.

(b) *Seal Installation:*

The compression seal shall be installed in accordance with the manufacturer's instructions. After installation, the top of seal shall be ¼ inch +- 1/16 inch from the top of concrete pavement.

Upturn and downturn bends shall be cut per the manufacturer's recommendations.

The initial concrete surface preparations and installations of the compression seal shall be performed by the Contractor in the presence of a qualified technical representative of the manufacturer. This representative shall be experienced in such installations and provide information to the Contractor on handling and installation procedures. The representative shall provide information to the Engineer on inspection of the seal installation and shall provide assistance until the representative, Contractor and the Engineer agree that they understand this installation and inspection procedures.

Subsection 518.12 shall include the following:

Bridge Compression Joint Seal will be measured as the actual number of lineal feet of seal that is installed and accepted from curb to curb.

Subsections 518.13 shall include the following:
Payment will be made under:

Pay Item	**Pay Unit**
Bridge Compression Joint Sealer	Linear Foot

Payment will be full compensation for all work necessary to complete the item including removal of any existing seals and concrete, saw cutting, sandblasting, surface cleaning and preparation, and installing of new compression seals as required to complete the work. All removed seals shall be disposed of by the Contractor.

Surface preparation and adhesive lubricant will not be measured and paid for separately, but shall be included in the work. Costs for the on-site qualified technical representative of the manufacturer shall be included in the work.

End of Section

Revision of Section 601
Concrete (Patching)

Section 601 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of furnishing and placing concrete patching material in accordance with these specifications and in conformity with the lines, grades and dimensions as shown on the plans or established.

MATERIALS

The concrete patching material may be pre-packaged Concrete patching material or Class DR concrete.

(a) *Pre-Packaged Concrete Patching Material.* Concrete patching material shall be polymer modified hydraulic cement and shall be one of the following:

(1) Rapid Set DOT Concrete Mix as manufactured by:
CTS Cement Manufacturing Company
11065 Knott Avenue
Cypress, CA 90630

(2) Rapid Road Repair as manufactured by
The QUIKRETE Companies
500 Marathon Parkway
Lawrenceville, Georgia 30046

(3) HD 50 as manufactured by
Dayton Superior Corp.
1125 Byers Road
Miamisburg, Ohio 45342

(4) or approved equal

Alternative concrete patching materials shall demonstrate 1/32-inch maximum mid panel and end crack widths, 0 percent delamination, and 0 percent spalling as tested by National Transportation Product Evaluation Program (NTPEP) in a one-year field evaluation. The Contractor shall refer to rapid-set concrete patch materials at www.ntpep.org.

Before January 1, 2020 equivalent materials may be tested to meet minimum requirements by an independent testing lab or NTPEP. If the product has not been field tested by NTPEP, the Contractor shall submit documentation of a project demonstrating the successful use of the proposed product in Colorado. The submittal shall document the material used, the project location and detailed pictures of the patch after at least 1 year of service.

The Contractor shall obtain and provide to the Engineer documentation from the Concrete patching material supplier of the expiration dates of the material components that will be used on the project.

Concrete patching material shall attain an average compressive strength of at least 2,500 psi prior to placing traffic and 4,500 psi at 28 days. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. The compressive strengths shall be used to develop

a strength versus time curve for the material. Three strength data points shall be determined to assess the necessary time to wait before traffic is allowed on the material. Maturity meter data may also be submitted to allow the use of maturity meter to determine when the patching material has gained the required strength for opening to traffic.

Concrete patching material shall provide a minimum bond strength of 2,000 psi at 28 days, as tested by ASTM C882.

Concrete patching material shall have a relative durability factor greater than 90 and a mass loss not to exceed 2.0 percent as tested by ASTM C666.

Concrete patching material shall have a maximum expansion of 0.05 percent, at 28 days as tested by ASTM C157

ASTM C39, C109, C882 and C157 testing shall be from the same lot of concrete patching material being used on the project. A CTR, in accordance with subsection 106.13, shall be submitted to the Engineer for approval at least 2 weeks prior to placement.

Two bags of the concrete patching material, and two bags of the extending aggregate if used, from the same lot to be used on the project shall be submitted to an accredited Lab to verify compressive strength, and set time properties, by the Contractor before the concrete patching material is to be used on the project. Test results shall be submitted to the Engineer for acceptance. Verification of the strength properties will be achieved if the test results are either equal in strength or stronger than those advertised. Verification of the set time will be achieved if the set time is equal or less than the advertised value. Testing shall be included in the cost of the materials. Test results from other projects using the same lot may be submitted. If the project uses material from more than one lot, test results are required for each lot used.

When Anodes are specified and are to be installed with pre-packaged concrete patching material, the Contractor shall submit test results of ASTM C1760 that the concrete patching material has an electrical resistivity of 15,000 Ohm-centimeters or less. Concrete patching materials that do not meet the electrical resistivity requirements may be used with special anode installation methods recommended by the anode manufacturer and approved by the Engineer. Additional work for special anode installation methods shall be included in the bid price.

(b) *Class DR Concrete.* Class DR Concrete shall have a minimum cement content of 615 pounds per cubic yard, an air content of 5 to 8 percent, a maximum water to cement ratio of 0.44, a minimum 6 hour compressive strength of 2,500 psi and a minimum 28 day compressive strength of 4,500 psi. The concrete mix shall consist of a minimum of 50 percent AASHTO M 43 Size No. 7 or Size No. 8 coarse aggregate by weight of total aggregate. Lab test results shall show that the unrestrained shrinkage is less than 0.050 percent when tested by CP-L 4103.

ASTM C150 Type III or ASTM C1157 Type HE cement may be used for Concrete Class DR, as approved.

The Contractor shall develop maturity relationships in accordance with CP 69. The Contractor shall provide a multi-channel maturity meter and all necessary wire and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meter and wire. Placement shall be as directed by the Engineer.

CONSTRUCTION REQUIREMENTS

(a) *Pre-Packaged Concrete Patching Material.* Concrete patching material shall be placed in the repair areas before the expiration date of the material. Proportions of all mix components shall be measured by volume measurement (number of bags of standard weight and quantity of water or liquid component in gallons or quarts). If partial bags are used the bagged mix, extending aggregate, and water shall be weighed on a calibrated scale provided by the Contractor. The Contractor shall submit the Concrete patching material mix design for approval two weeks before any concrete patching material is placed. The Contractor shall also submit a method statement describing what type of equipment will be used to batch the patching material, including the type of mixer, the type of material, volume measures to be used, scales for partial bags, procedures to insure accurate proportioning of the patching material components, and tools to be used in placing and finishing the surface of the patch.

The Contractor shall produce a batch ticket for each mixed batch of concrete patching material with the following information shown on each ticket:

(1) Project No.
(2) Bridge No.
(3) Structure Temperature
(4) Date and Time of batch
(5) Material Type, name, and manufacturer
(6) Material expiration date
(7) Weight or volume of bag mix concrete
(8) Weight or volume of extending aggregate
(9) Weight or volume of water or liquid component
(10) Location of placement (Lane and Station Limits)

The tickets shall be available on site for CDOT personnel to inspect.

Each day the Contractor shall provide to the Engineer tickets for each bridge in separate envelopes stating Project Number, Bridge Number, Date of Paving, Type of Material, Daily Total, and Cumulative Total.

Concrete patching material minimum and maximum thicknesses shall be per recommendation of the material manufacturer.

Concrete patching material site preparation, batching, extending with aggregate, mixing, placement, placement during cold temperatures, consolidation, and curing shall be in accordance with the manufacturer's recommendations. A mix may be extended up to 90 percent of the manufacturer's maximum extension.

The surface of concrete patching material shall have a similar texture as the adjacent driving surfaces.

The Contractor shall submit a report consisting of the mix proportions and compressive strength vs time curve information to the Engineer at least two weeks before the material is to be used on the project.

Field cast cylinders or cubes shall be taken by a qualified testing representative, with a minimum ACI Field Testing Technician Grade I certification, and test results shall be submitted to the Engineer within 24 hours, the first day and every other subsequent day deck patching material is placed with compressive strength determined at 24 hours according to ASTM C 39 or ASTM C109.

Areas patched with Concrete (Patching) shall not be opened to traffic until concrete patching material

has reached a compressive strength of 2,500 psi using the compressive strength versus time curve developed for the material.

(b) Class DR Concrete. Class DR Concrete shall meet all requirements of Class D concrete with the these additional requirements:

The area to be patched with Class DR Concrete and anodes shall be saturated surface dry before placement and shall be free of standing water at the time of placement.

Portions of decks patched with Concrete Class DR shall not be opened to traffic until the concrete's compressive strength, determined by CP 69, has achieved at least 2500 psi.

Concrete Class DR shall be cured until a compressive strength of at least 2500 psi has been achieved. The curing compound shall conform to ASTM C309, Type 2 applied at a rate of 1 gallon per 100 square feet. The curing compound shall be applied as a fine spray within 10 minutes of discontinuing the finishing operation. Before and during application the curing compound shall be kept thoroughly mixed. Curing blankets with a minimum R-value of 0.5 shall be provided and shall be placed as soon as they can be placed without marring the surface. When the ambient temperature is below 50°F, the Contractor shall maintain the concrete temperature above 50°F during the curing period.

METHOD OF MEASUREMENT

Concrete (Patching) will be measured and paid for as the actual quantity placed and accepted by the Engineer.

BASIS OF PAYMENT

The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Pay Item	Pay Unit
Concrete (Patching)	Cubic Yard
Concrete (Patching)	Cubic Feet

Payment for Concrete (Patching) will be full compensation for all the work, materials, tools, equipment, testing, and incidentals required to complete patching, excluding special installation of anodes when specified, when required.

Furnishing all appurtenances including the molding, curing and breaking of cylinders or cubes for generating the strength versus time curve and for determining the information cylinder or cube strength will not be measured and paid for separately, but shall be included in the work. Concrete patching material or Class DR Concrete will not be measured and paid for separately, but shall be included in the Concrete (Patching) bid item.

End of Section

Revision of Section 630
Traffic Control Management

Section 630 of the Standard Specifications is hereby revised for this project as follows:

Subsection 630.17 paragraph 7 shall be replaced with the following:

The quantity to be measured for Traffic Control Management (TCM) shall be the actual number of authorized 24-hour periods that the TCM is used. If a TCM is required on multiple schedules simultaneously, within a 24-hour period, the Contractor shall utilize one TCM per schedule and will be paid one (1) day for each TCM that is on site. The Contractor shall not be paid for more than one TCM per schedule per 24-hour period. The actual number of TCM days shall be approved by the DEN Project Manager prior to the work.

End of Section

Revision of Section 630
Mobile Attenuator

Section 630 of the Standard Specifications is hereby revised for this project as follows:

Subsection 630.01 shall include the following:

This work shall consist of furnishing, operating, and maintaining a truck with an attached impact attenuator.

Subsection 630.09 shall include the following:

Mobile Attenuator Options:

Truck Mounted Attenuator
The Contractor shall supply a vehicle with a truck mounted attenuator approved by the FHWA to meet NCHRP 350 criteria for level TL-3 collisions. The attenuator shall be mounted to a suitable truck in a manner meeting the Manufacturer's specifications. The truck shall be furnished with a roof mounted Advance Warning Flashing or Sequencing Arrow Panel (B Type). The truck shall be used when setting up or taking down the work zone and shall be parked in the activity area protecting the construction work while work is being performed, unless otherwise directed.

Trailer Attenuator
The Contractor shall supply a vehicle with an attached trailer attenuator approved by the FHWA to meet NCHRP 350 criteria for level TL-3 collisions. The trailer attenuator shall be attached to a suitable host truck in a manner meeting the Manufacturer's specifications, to include factory-installed 20-ton (minimum) rated pintle hook and ½-inch (minimum) steel frame plate, or as specified by Manufacturer. The trailer shall be furnished with a mounted Advance Warning Flashing or Sequencing Arrow Panel (B Type).

The weight of the host truck shall be between 10,000 and 20,000 lbs, or as specified by the trailer attenuator manufacturer. The Contractor shall provide a certified scale ticket confirming the weight of the truck without trailer attached.

The Trailer Attenuator attached to its host truck shall be used when setting up or taking down the work zone and shall be parked in the activity area protecting the construction work while work is being performed, unless otherwise directed. A buffer zone shall be provided in front of the host truck, for worker safety. This buffer zone shall be in accordance with the manufacturer's recommendations, but shall be no less than 100 feet in length, unless otherwise directed.

Subsection 630.13 shall include the following:

Maintenance, storage, operation, and all repairs of Mobile Attenuator and associated vehicle shall be the responsibility of the Contractor.

Subsection 630.15 shall include the following:

Mobile Attenuators will be measured as the actual number of authorized 24-hour periods that the attenuator is used. In the event that a Mobile Attenuator is required on multiple schedules simultaneously, within a 24 hour period, the Contractor shall be paid one (1) day for each unit that is on site. The Contractor shall not be paid for more than one Mobile Attenuator per schedule per 24-hour period. Mobile Attenuators shall be shown on the Method of Handling Traffic (MHT) and shall be approved by the DEN Project Manager prior to their use.

Subsection 630.16 shall include the following:

Pay Item		Pay Unit
630-85041	Mobile Attenuator	Day

Payment will be full compensation for all labor, materials and equipment required to operate and maintain the truck and attenuator for the duration of the project, including the attenuator and flashing panel.

End of Section

Revision of Section 630
Traffic Control Plan – General

The key elements of the Contractor's Method of Handling Traffic (MHT) are outlined in subsection 630.09. Special Traffic Control Plan requirements for this project are as follows:

For construction impacting inbound or outbound Peña Boulevard:

All lanes must be maintained and open to traffic at all times, except as provided for in an approved DEN Shutdown Request (see below). Aside from allowances provided for in an approved DEN Shutdown Request or from DEN Operations approval, lane rental fees will be assessed against the Contractor if the lanes are not re-opened to traffic by the approved time. During approved nightly closures, no traffic control devices shall be placed on the roadway prior to receiving approval from the DEN Project Manager or designated representative.

The Contractor's MHT submittals shall include information regarding construction access between the Peña Boulevard lanes or ramps, and the construction areas.

One-lane may be closed during the following hours with an approved DEN Shutdown Request, as per Division 1 Specifications:

- Weekday and Weekend – Inbound Pena Blvd 8:00 PM to 4:00 AM
- Weekday and Weekend – Outbound Pena Blvd 11:00 PM to 7:00 AM

If the Contractor elects to provide an alternate traffic control plan, the Contractor shall submit a new Traffic Control Plan per requirements in Section 015525 of the DEN Division 1 General Requirements for approval.

DEN Operations and/or the DEN Project Manager reserve the right to reduce or change the working hours and/or cancel nightly closures based upon operational, safety, or security needs of the Airport. All cost associated with delays or cancellations of the nightly closure shall be incidental to the work.

The Contractor shall be responsible for any physical or environmental impacts associated with the construction.

All costs incidental to the foregoing requirements shall be included in the original contract prices for the project.

End of Section

Division 02 – CDOT Standard Special Provisions

Revision of Section 105
Conformity to the Contract of Portland Cement Concrete Pavement

Section 105 of the Standard Specifications is hereby revised for this project as follows:

In subsection 105.06(a) delete the third paragraph and replace it with the following:

When compressive strength criteria is indicated, then the QL will be calculated for the elements of compressive strength and pavement thickness on a process basis. When flexural strength criteria is indicated, then the QL will be calculated for the elements of flexural strength and pavement thickness on a process basis. A process will consist of the test results from a series of random samples. Test results determined to have sampling or testing errors will not be used. All materials produced will be assigned to a process. Changes in mix design, design pavement thickness, or a break of more than 120 working days between placements will create a new process. The following is provided to clarify changes in processes for each element:

1. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the compressive or flexural strength element, when the mix design does not change and there is not a break of more than 120 days between placements.

2. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process for the thickness element, when the planned thickness does not change and there is not a break of more than 120 days between placements.

3. Construction of ramps, acceleration and deceleration lanes and shoulders placed separately are considered separate processes.

4. Changes in paving equipment, changes in placement method, changes in hauling equipment, adjustments to mix designs that do not require a new mix design, changes in weather conditions, and changes in production rate shall not create a new process in the strength or thickness elements.

The Contractor and Engineer will determine element processes and what distinguishes them as processes during the pre-pave meetings prior to any concrete placement.

End of Section

Revision of Section 106
Conformity to the Contract of Hot Mix Asphalt

Section 106 of the Standard Special Provisions is hereby revised for this project as follows:

Subsection 106.05 shall include the following:

For this project, Contractor process control testing of hot mix asphalt is mandatory.

End of Section

Revision of Section 106
Conformity to the Contract of Hot Mix Asphalt (Less Than 5000 Tons)

Section 106 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 106.05 and replace with the following:

106.05 Sampling and Testing of Hot Mix Asphalt. All hot mix asphalt, Item 403, except Hot Mix Asphalt (Patching) and temporary pavement shall be tested in accordance with the following program of process control testing and acceptance testing:

The Contract will specify whether process control testing by the Contractor is mandatory or voluntary.

Process Control Testing.

1. Mandatory Process Control. When process control testing is mandatory the Contractor shall be responsible for process control testing on all elements and at the frequency listed in Table 106-1. Process control testing shall be performed at the expense of the Contractor.

   After completion of compaction, in-place density tests for process control shall be taken at the frequency shown in Table 106-1. The results shall be reported in writing to the Engineer on a daily basis. Daily plots of the test results with tonnage represented shall be made on a chart convenient for viewing by the Engineer. All of the testing equipment used for in-place density testing shall conform to the requirements of acceptance testing standards, except nuclear testing devices need not be calibrated on the Department's calibration blocks.

   For elements other than in-place density, results from process control tests need not be plotted, or routinely reported to the Engineer. This does not relieve the Contractor from the responsibility of performing such testing along with appropriate plant monitoring as necessary to assure that produced material conforms to the applicable specifications. Process control test data shall be made available to the Engineer upon request.

2. Voluntary Process Control. The Contractor may conduct process control testing. Process control testing is not required, but is recommended on the elements and at the frequency listed in Table 106-1.

   All of the testing equipment used for in-place density testing shall conform to the requirements of acceptance testing standards, except nuclear testing devices need not be calibrated on the Department's calibration blocks.

(a) *Acceptance Testing.* Acceptance testing is the responsibility of the Department. For acceptance testing the Department will determine the locations where samples or measurements are to be taken and as designated in Section 403. The maximum quantity of material represented by each test result, the elements, the frequency of testing and the minimum number of test results will be in accordance with Table 106-1. The location or time of sampling will be based on the stratified random procedure as described in CP 75. Acceptance sampling and testing procedures will be in accordance with the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual. Samples for project acceptance testing shall be taken by the Contractor in accordance with the designated method. The samples shall be taken in the presence of the Engineer. Where appropriate, the Contractor shall reduce each sample to the size designated by the Engineer. The Contractor may retain a split of each sample which cannot be included as part of the Contractor's process control testing. Dispute of the acceptance test results in accordance with CP-17 will not be allowed unless a provision for check testing has been included in the Contract and it has been successfully completed. All materials being used are subject to inspection and testing at any time prior to or during incorporation into the work.

Table 106-1
SCHEDULE FOR MINIMUM SAMPLING AND TESTING FOR HMA

Element	Process Control	Acceptance (1)
Asphalt Content	1/500 tons	1/1000 tons
Theoretical Maximum Specific Gravity	1/1000 tons, minimum 1/day	1/1000 tons, minimum 1/day
Gradation (2)	1/Day	1/2000 tons
In-Place Density	1/500 tons	1/500 tons
Joint Density	1 core/2500 linear feet of joint	1 core /5000 linear feet of joint
Aggregate Percent Moisture (3)	1/2000 tons or 1/Day if less than 2000 tons	1/2000 tons
Percent Lime (3) (4)	1/Day	Not applicable

Notes:

(1) The minimum number of in-place density tests for acceptance will be 5.

(2) Process control tests for gradation are not required if less than 250 tons are placed in a day. The minimum number of process control tests for gradation shall be one test for each 1000 tons or fraction thereof.

(3) Not to be used for incentive/disincentive pay. Test according to CP 60B and report results from Form 106 or Form 565 on Form 6.

(4) Verified per Contractor's PC Plan.

(b) *Reference Conditions.* Three reference conditions can exist determined by the Moving Quality Level (MQL). The MQL will be calculated in accordance with the procedure in CP 71 for Determining Quality Level (QL). The MQL will be calculated using only acceptance tests. The MQL will be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter on the last five consecutive test results. The MQL will not be used to determine pay factors. The three reference conditions and actions that will be taken are described as follows:

1. Condition green will exist for an element when an MQL of 90 or greater is reached, or maintained, and the past five consecutive test results are within the specification limits.

2. Condition yellow will exist for all elements at the beginning of production or when a new process is established because of changes in materials or the job-mix formula, following an extended suspension of work, or when the MQL is less than 90 and equal to or greater than 65. Once an element is at condition green, if the MQL falls below 90 or a test result falls outside the specification limits, the condition will revert to yellow or red as appropriate.

3. Condition red will exist for any element when the MQL is less than 65. The Contractor shall be notified immediately in writing and the process control sampling and testing frequency increased to a minimum rate of 1/250 tons for that element. The process control sampling and testing frequency shall remain at 1/250 tons until the process control QL reaches or exceeds 78. If the QL for the next five process control tests is below 65, production will be suspended.

If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the first 1250 tons produced in condition red. If this test result is outside the tolerance limits, production will be suspended. (This test result will not be included as an acceptance test.)

After condition red exists, a new MQL will be started. Acceptance testing will stay at the frequency shown in Table 106-1. After three acceptance tests, if the MQL is less than 65, production will be suspended.

Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

Upon resuming production, the process control sampling and testing frequency for the elements causing the condition red shall remain at 1/250 tons. If the QL for the next five process control tests is below 65, production will be suspended again. If gradation is the element with MQL less than 65, the Department will test one randomly selected sample in the first 1250 tons produced in condition red. If this test result is outside the tolerance limits, production will be suspended.

End of Section

Revision of Section 403
Hot Mix Asphalt

Section 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 403.02 shall include the following:

The Contractor shall prepare a quality control plan outlining the steps taken to minimize segregation of HMA. This plan shall be submitted to the Engineer and approved prior to beginning the paving operations. When the Engineer determines that segregation is unacceptable, the paving shall stop and the cause of segregation shall be corrected before paving operations will be allowed to resume.

The hot mix asphalt shall not contain any reclaimed asphalt pavement.

Hot mix asphalt for patching shall conform to the gradation requirements for Hot Mix Asphalt (Grading S) or (Grading SX) at the discretion of the engineer.

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all hot mix asphalt.

Acceptance samples shall be taken at the location specified in Method A,B, or C of CP 41. The Contractor's preferred method (A,B or C of CP41) shall be discussed at the pre-pave meeting.

Subsection 403.03 shall include the following:

The Contractor shall use an approved anti-stripping additive. The amount of additive used shall be a minimum of 0.5 percent by weight of the asphalt cement. The additive shall be added at the refinery or at the hot plant. If liquid anti-stripping additive is added at the plant, an approved in-line blender must be used. The blender shall be in the line from the storage tank to the drier drum or pugmill. The blender shall apply sufficient mixing action to thoroughly mix the asphalt cement and anti-stripping additive.

The Contractor shall construct the work such that all roadway pavement placed prior to the time paving operations end for the year, shall be completed to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

Delete subsection 403.05 and replace with the following:

403.05 The accepted quantities of hot mix asphalt will be paid for in accordance with subsection 401.22, at the contract unit price per ton for the bituminous mixture.

Payment will be made under:

Pay Item	**Pay Unit**
Hot Mix Asphalt (Grading S)(75)(PG 64-22)	Ton
Hot Mix Asphalt (Grading SX)(75)(PG 64-22)	Ton
Hot Mix Asphalt (Patching)(Asphalt)	Ton

Aggregate, asphalt recycling agent, asphalt cement, additives, hydrated lime, and all other work and materials necessary to complete each hot mix asphalt item will not be paid for separately, but shall be included in the unit price bid. When the pay item includes the PG binder grade, any change to the submitted mix design optimum asphalt cement content to establish production targets on the Form 43 will not be measured and paid for separately, but shall be included in the work. No additional compensation will be considered or paid for any additional asphalt cement, plant modifications and additional personnel required to produce the HMA as a result in a change to the mix design asphalt cement content.

Historically, typical asphalt cement increases reflected on the Form 43 are from 0.1 to 0.5 percent. However, the Contractor should anticipate the AC increases typical of his mixes. Contractors bidding the project should anticipate this change and factor it into their unit price bid.

When the pay item does not include the PG binder grade, asphalt cement will be measured and paid for in accordance with Section 411. Asphalt cement used in Hot Mix Asphalt (Patching) will not be measured and paid for separately, but shall be included in the work.

Excavation, preparation, and tack coat of areas to be patched will not be measured and paid for separately, but shall be included in the work.

End of Section

Revision of Section 703
Classification of Aggregate Base Course

Section 703 of the Standard Specifications is hereby revised for this project as follows:

In subsection 703.03, delete Table 703-2 and replace with the following:

Table 703-2
CLASSIFICATION FOR AGGREGATE BASE COURSE

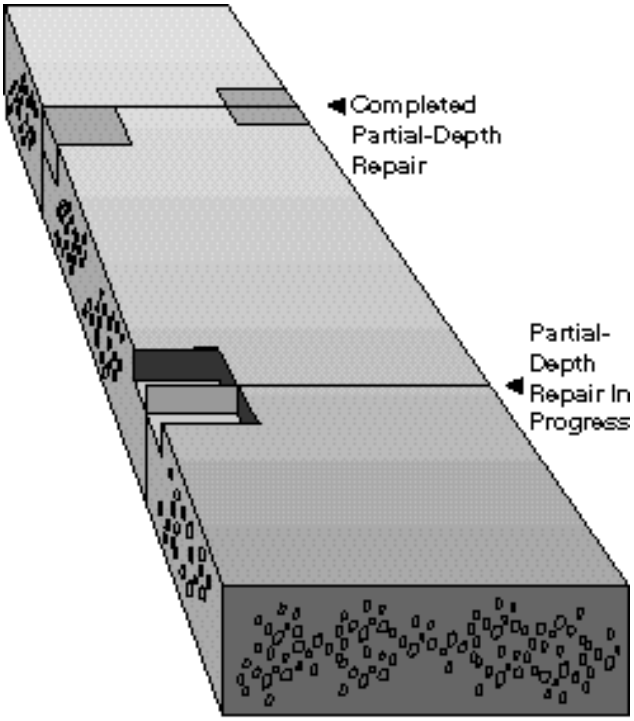
Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
150mm (6")			100				
100mm (4")		100					
75mm (3")		95-100					
60mm (2 ½")	100						
50mm (2")	95-100			100			
37.5mm (1.5")				90-100	100		
25mm (1")					95-100	100	100
19mm (3/4")				50-90		95-100	
4.75mm (#4)	30-65			30-50	30-70	30-65	
2.36mm (#8)						25-55	20-85
75 □m (#200)	3-15	3-15	20 max	3-12	3-15	3-12	5-15
NOTE: Class 3 material shall consist of bank or pit run material.							

End of Section

APPENDIX A
AMERICAN CONCRETE PAVEMENT ASSOCIATION (ACPA)
TECHNICAL BULLETIN
GUIDELINES FOR PARTIAL-DEPTH REPAIR

CONCRETE PAVING *Technology*

Guidelines for Partial-Depth Spall Repair



PURPOSE

This publication provides guidance for repairing spalling at joints and cracks in concrete pavement slabs. These recommendations apply to pavements for highways, streets and roads, and airports.

INTRODUCTION

Partial-depth repair is a rehabilitation technique that restores localized surface distress, such as spalling at joints and/or cracks in the upper one-third to one-half of a concrete pavement. Surface spalls create a rough ride and can accelerate development of further problems. Partial-depth patches replace unsound concrete, restore the rideability of the pavement, deter further deterioration, and provide suitable edges for effective joint and crack resealing.

Partial-depth patches are usually very small. Each patch typically covers an area less than about 1 sq. m (1.2 sq. yd) and are often only 50-75 mm (2-3 in.) deep. Installing a partial-depth repair involves determining the extent of the deterioration, removing the deteriorated concrete, cleaning the patch area, placing the patch material, and re-forming the joint system.

The most common problem partial-depth repair is used for is spalling, but it can also be used for small areas with severe scaling. Spalling is the breaking, cracking, chipping, or fraying of the slab edges that occurs within 50 mm (2 in.) of joints and cracks or their corners. (1) Spalling differs from cracking in that a crack is a fracture through most or all the thickness of the slab. A typical transverse joint spall for which partial-depth repair would be appropriate is shown in Figure 1.

Figure 1. Transverse joint spalling.

One of the causes of spalling is the obstruction of joint closure due to incompressibles in the joint system. Incompressibles are sands, small stones, and fragments of concrete that become lodged in joints and cracks when they are open during cool weather. When the slabs expand in hot weather, the incompressibles inhibit the closing of the joints and cracks. This sets up uneven point-bearing pressures at the joint or crack face, which cause the concrete to crush or spall.

Another cause of spalling is the use of plastic or metal joint-forming inserts. Joints constructed with plastic inserts often require extra finishing, which can draw water to the surface. This increases the water-cement ratio of the paste at the surface and makes the surface susceptible to spalling and scaling. Similarly, metal joint-forming inserts, sometimes called unitube, and high reinforcing steel can cause spalling if placed too close to the surface. Corrosion and expansion of the steel or inserts, or entrapment of incompressibles in the inserts, can lead to cracking, breaking, and debonding of the surrounding concrete.

Finally, late sawing and material durability problems such as alkali-silica reactivity (ASR), D-cracking, or freeze-thaw damage can cause spalling. Late sawing may induce micro-fracturing at the joint face, which could break off and cause spalling. Material problems cause the concrete joint face to deteriorate and spall.

Spalls that are smaller than 50 mm (2 in.) by 150 mm (6 in.) do not affect ride quality and do not need partial-depth repair. Individual small spalls adjacent to joints or cracks can simply be filled with sealant. However, when several small spalls exist along a joint or crack, it may be preferable to repair the full length of the spalled area.

Limitations —

Partial-depth repair is usually not appropriate for visible spalls that extend more than 150-250 mm (6-10 in.) from the joint and are moderately severe. Such spalls may indicate that more deterioration is taking place below the slab surface. These spalls are often caused by material problems, such as D-cracking, ASR, or by corrosion or lockup of dowel bars at transverse joints. Full-depth repair is more appropriate for these distresses (Figure 2). If there is no obvious indication of the depth or cause of the spalling, coring is necessary to determine whether deterioration exists below the surface. For more information on full-depth repairs, see ACPA publication *Guidelines for Full-Depth Repair (TB002P).* [2]

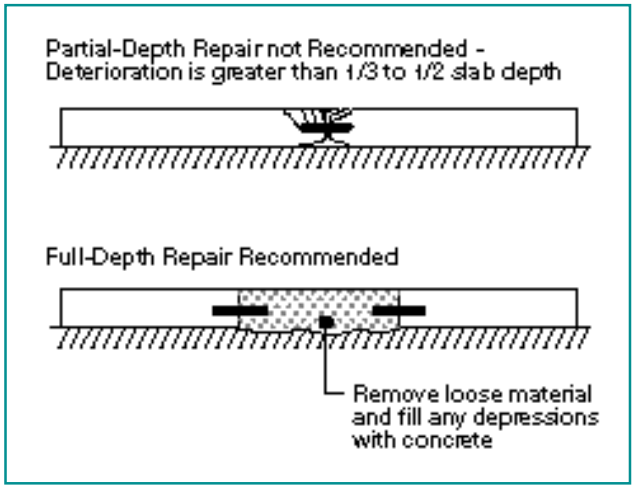


Figure 2. Joint deterioration warranting full-depth repair.

A partial-depth repair cannot correct a crack through the full thickness of the slab. Depending on the cracks condition, either sawing and sealing or full-depth repair is the appropriate repair for cracking. However, surface spalling at a crack can be corrected by partial-depth repair, as long as the crack itself is reestablished through the partial-depth repair and subsequently sealed.

Partial-depth repairs should not be used to repair spalling caused by corrosion of metal joint-forming inserts or reinforcing steel if the metal is to be left in place. All metal must be removed before placing a

partial-depth repair. In general, partial-depth repairs should be applied only to spalls that are confined to the upper one-third to one-half of the slab thickness and do not expose reinforcing steel or load transfer devices. If it is possible to cut and fully remove the reinforcing steel exposed in the spalled area, (as in the case of mesh reinforcement placed too high), a partial-depth repair can be successful, as long as the spall is no deeper than one-third to one-half of the slab thickness.

Pavements that have little remaining structural life, as evidenced by a substantial amount of fatigue cracking and/or rapid crack deterioration, are not good candidates for partial-depth repairs or other non-overlay restoration techniques. A concrete overlay or reconstruction is a better rehabilitation alternative in this situation.

DESIGN

Concurrent Work —

Partial-depth repair may be done either alone or as part of a comprehensive concrete pavement restoration (CPR) project. When done as part of a comprehensive project, the sequence of partial-depth repair and other restoration techniques is important. Figure 3 illustrates where partial-depth repair fits into the overall scheme of a restoration program. [3,4]

Partial-depth repair should be done after slab stabilization, so that any accidental spalling that may occur during slab stabilization can be repaired. It should be done before or concurrently with full-depth repair, so that either a partial-depth or a full-depth repair can be done depending on the depth of the deterioration. Partial- and full-depth repair should precede diamond grinding, which restores the rideability of the pavement to a high smoothness level.* These techniques are followed by joint resealing. One of the objectives of partial-depth repair is to provide new joint edges suitable for resealing. For more information on these other restoration techniques, see references 2-8.

* A good finishing technique can create an adequate transition between the patch and the existing concrete. However, if the pavement will have many closely spaced repairs, it may be difficult to achieve a surface smoothness comparable to modern standards. In such cases, it is necessary to restore the ride quality with diamond grinding.

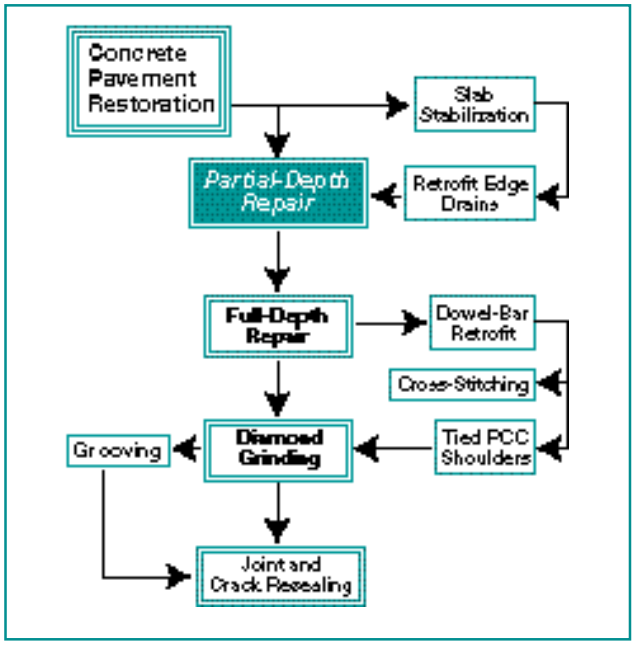


Figure 3. Location of Partial-depth repair in an overall Concrete Pavement Restoration sequence.

CPR - Area Management — Because the distresses that partial-depth repairs repair are progressive (that is, they get worse if neglected), it is important that they be repaired as timely as possible. One way to do this is with the "CPR - Area Management" concept.

CPR - Area Management is a multiyear contract between a highway or airport agency and a contractor to repair and manage pavement deterioration. The agency contracts for very broad CPR quantities, certain traffic-control windows, and distress surveys. The contractor commits to specific unit prices based on broad quantities, without exact areas or items marked on the pavement or plans.

After the contract award, the agency and contractor jointly conduct a detailed distress survey and agree on the specific repairs for that year. After determining the amount of work, the contractor develops a site-specific work plan and traffic control scheme. Finally, the agency issues a work order to begin work. The sequence is repeated in successive years. [4]

Size —

Good judgment is essential in defining the limits for partial-depth repairs, particularly where more deterioration exists than is visible on the slab surface. Some engineers attempt to cut costs by limiting patch size despite the expanse of deterioration, which can

reduce the repair's ability to extend pavement service life. Furthermore, for partial-depth patches, the cost is in the labor and not in the materials.

To size a repair, it is necessary to know the extent of typical deterioration on the pavement. Each repair should replace the concrete and all significant distress. It is also advantageous to keep the patch boundaries square or rectangular, and to avoid internal corners in the patch area. Irregular shapes and internal corners are more difficult to saw and usually do not perform well.

It may be necessary to extend the size of patches beyond the minimum length when marking the pavement removal areas just before construction. Use the following guidelines when determining the repair sizes:[9]

- Use a minimum length of 300 mm (12 in.).
- Use a minimum width of 100 mm (4 in.).
- Extend the patch limits beyond the delamination marks or visible spalls by 75-100 mm (3-4 in.).
- Do not place a patch if the spall is less than 150 mm (6 in.) long and less than 35 mm (1.5 in.) wide.
- If two patches will be less than 0.6 m (2 ft) apart, combine them into one large patch.
- Repair the entire joint length if there are more than two spalls along a transverse joint.

It is during removal of the concrete that you determine the depth of the patch. See Figure 4 for a typical layout for a partial-depth repair.

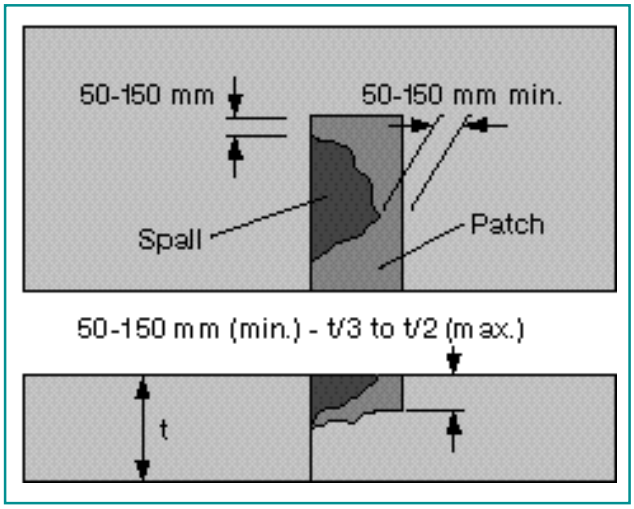


Figure 4. Typical patch layout for a partial-depth repair

Material Selection —

The selection of the patching material depends on many factors. These include time available before opening to traffic, air temperature during construction, funding, desired service life, and the size and the depth of the patches. The ideal partial-depth repair material would have good workability, quick mixing time, fast setting time, rapid strength development, low shrinkage, strong bonding capability, good long-term strength and durability, thermal compatibility with the existing concrete, and a reasonable cost.

Among the material properties that should be considered are strength gain, modulus of elasticity, bond strength, freeze-thaw resistance, scaling resistance, sulfate resistance, abrasion resistance, coefficient of thermal expansion, and shrinkage. References 10, 11, 12, and 13 present laboratory test results from several organizations on a variety of different repair products and include suggested specifications.

Volume change refers to shrinkage of the material due to moisture loss or contraction and expansion due to temperature changes. Excessive volume change can cause the repair material to debond from the surrounding concrete, and may cause cracking within the repair material itself. Some repair materials can be mixed with agents that will decrease the likelihood of debonding and shrinkage cracking. Some of the factors that influence the degree of volume change are the size of the aggregate, the water-cement ratio (for cementitious mixtures), and retention of heat and moisture during curing.

Rapid strength development is important when downtime must be minimized. The rate of strength development is influenced by the properties of the repair material as well as the ambient temperatures during placement and the curing methods used. Both cement and epoxy materials will gain strength more slowly at low temperatures.

The cost of using any repair material depends not only on the material costs itself but also labor time for mixing and placement, equipment requirements, curing requirements, and allowable closure time. These costs may be different for different repair materials.

Repair Materials —

Cementitious Repair Materials —

Normal concrete mixtures containing Type I cement (ASTM C150) [14] may be used when the repairs can be protected from traffic for 24 hours or more.[15] A set accelerator may be added to the mix to reduce the setting time. The aggregate used in the repairs should have a maximum size no greater than one-half the minimum repair depth.

These repairs are usually bonded to the existing concrete with a grout, which consists of sand and cement in a 1:1 ratio by volume and enough water to produce a creamy consistency. The repair material must be placed before the grout dries. If the grout is left exposed long enough to dry, the repair area must be cleaned by sandblasting and the grout reapplied.

Normal-strength concrete repair mixtures should not be placed when the air temperature is below 4°C (40°F). At temperatures below 13°C (55°F), a longer curing period and/or insulation mats may be required.

High-early-strength PCC mixtures usually containing Type III cement (ASTM C150) [14] with or without admixtures, can gain strengths in excess of 21 MPa (3000 psi) within 24 hours. These are usually used when early opening to traffic (e.g., 4 hours) is required.[15] An epoxy bonding agent is usually used with these mixtures. The repair material is placed when the epoxy becomes tacky.

Specialty cement mixtures contain some kind of cement in place of or in addition to normal Type I or Type III cement. This may be some other hydraulic cement, a gypsum-based cement, magnesium phosphate cement, or high-alumina cement, for example.

- **Gypsum-based (calcium sulfate) cement mixtures** can gain strength rapidly and can be used in temperatures above freezing and up to 43°C (110°F). Some evidence suggests that these materials do not perform well when exposed to moisture and freezing temperatures. [16]

- **Magnesium phosphate and magnesium ammonium phosphate cement mixtures** can come in normal (fast) setting, intermediate setting, and retarded setting versions. Magnesium phosphate mixtures are normal setting mixes that set very rapidly, and so should be mixed in small quantities and worked rapidly. At temperatures below 27°C (81°F), the working time is about 10 minutes. At higher temperatures, the working time may be greatly reduced.

  The retarded setting mix is a magnesium ammonium phosphate cement mixture and it was developed to be used in southern states and on hot summer days when the temperature exceeds 29°C (85°F). This material produces similar properties to the regular magnesium phosphate materials when tested at 21°C (70°F). Intermediate magnesium ammonium phosphate mixes have setting times about half way between the regular setting and retarded setting versions.

  All these mixtures have low permeability and bond well to any clean and dry surface. However, the strength of these materials is sensitive to moisture content of the existing concrete materials. They cannot be used in pavements that contain limestone aggregates. The presence of limestone aggregates may be detected by wetting a freshly exposed concrete surface with vinegar. Bubbles will appear if the concrete contains limestone aggregates. [10, 17]

- **High-alumina cement mixtures** should not be used and are not recommended. They are susceptible to a conversion of some of its calcium aluminate hydrate components, which results in significant strength loss.

- **Accelerating admixtures/additives** such as calcium chloride, are sometimes added to cementitious patch materials to reduce the time to opening. Though this does not usually cause problems, the designer should be aware some patches may develop premature wear because the paste in the patch material may not get well cured.

- **Alumina powder** has been used as an admixture with Type I or Type III cement mixtures to counteract shrinkage. However, the reactivity of aluminum powder can be difficult to control in field proportioning, particularly in small batch operations. Furthermore, the use of alumina powder may decrease the bond strength and patch abra-

Table 1 : Properties of Partial-Depth Repair Materials [19]

Category	Working Time	Installation Temperature	Time to Traffic	Moisture Conditions of *	
				Repair Surface	Aggregate
Normal concrete mixtures	15 - 30 min.	4° - 43°C (40° - 110°F).	4 - 72 hours	SSD to dry	1-3% to dry
High-early-strength PCC mixtures	15 - 30 min.	0° - 43°C (32° - 110°F).	4 - 6 hours	SSD to dry	1-3% to dry
Gypsum-based (calcium sulfate) cement mixtures	15 - 30 min.	0° - 43°C (32° - 110°F).	1 - 2 hours	SSD to dry	1-3% to dry
Magnesium phosphate cement mixtures	5 - 45 min.	0° - 32°C (32° - 90°F).	1 - 2 hours	Dry	1-3% to dry
Epoxy-resin mortars or epoxy concretes	5 - 15 min.	4° - 32°C (40° - 90°F).	1 - 3 hours	Dry	Dry
Methyl-methacrylate concretes	30 - 60 min.	4° - 54°C (40° - 130°F).	1 - 2 hours	Dry	Dry
Polyurethane concretes	1 min.	> -18°C (> 0°F).	10 - 20 min.	Dry	Dry

* *SSD = Saturated Surface Dry; Dry = Oven-dried*

sion resistance. This results from the expansive nature of the alumina powder, which causes the density of the paste to decrease. An alternative is a shrinkage-compensating cement (ASTM C 845, Type K). [18]

- **Other rapid setting materials** are also available that can perform adequately. However, some rapid hardening repair materials are accelerated with high alkaline bearing materials. These materials may react with certain siliceous aggregates to form ASR. Therefore, it is important to make sure that no chemical incompatibilities exist between the patch material and the aggregates.

Specialty Repair Materials —

Rapid-strength proprietary materials must be placed according to the manufacturer's recommendations concerning bonding, placing, curing, and opening time. Preparation of the repair area should be done as described in this bulletin, except where the manufacturer's recommendations indicate otherwise. It is also very important to follow the manufacturer's recommendations concerning suitable temperature ranges for placement. Some proprietary materials are very sensitive to temperature and construction procedures.

Polymer concretes are a combination of polymer resin, aggregate, and a set initiator. The aggregate can range in size from sand to 9.5-mm (3/8 in.) stone. Polymer concrete are categorized by the type of resin used, such as epoxies, methacrylates, and polyurethane. [10, 17]

- **Epoxy-resin mortars or epoxy concretes** have been used since the 1950s. In general, they have excellent adhesive properties and low permeability. However, the setting times, placement temperature ranges, strengths, bonding capabilities, and abrasion resistance properties of various epoxy mixtures can vary widely. The particular epoxy mix under consideration should be carefully evaluated in the laboratory at the exposure extremes before use. The main disadvantage of epoxy concretes is that they are not thermally compatible with normal concrete, and this can sometimes result in early repair failure. Larger aggregate increases the volume stability and reduces the risk of debonding.

  Epoxy concretes should not be used to repair spalls caused by reinforcing steel corrosion because the epoxy can accelerate the corrosion

in the steel.[10,17] The epoxy resin catalyst should be preconditioned before blending.

The epoxy components should be mixed in strict compliance with the manufacturer's recommendations before aggregate is added.[15] The material should be blended in a suitable mixer until homogeneous. If the blended material begins to develop excessive heat, the material should be discarded. Depending on the manufacturer's recommendations, a priming coat of blended epoxy may be required.

- **Methyl-methacrylate concretes** have working times between 30 and 60 minutes, high compressive strengths, and adhere well to clean dry concrete. They can be placed over a wide range of temperatures from 4 to 54°C (40 to 130°F). A major concern with methyl methacrylates is their volatility and hazardous nature. The fumes pose a health hazard and can ignite if exposed to a spark or flame. High-molecular-weight methacrylate (HMWM) is a newer type of methacrylate that possesses many of the same properties as conventional methacrylate but without the volatility or health hazard.[10, 17]

- **Polyester-styrene concretes** are similar to methyl-methacrylate concretes, possessing many of the same properties, but having a much slower rate of strength gain. This limits their usefulness for partial-depth spall repair.

- **Polyurethane concretes** consist of a two-part polyurethane resin mixed with aggregate. These materials set very rapidly. Two types of polyurethane materials are currently available. The older type is moisture sensitive and foams when it comes into contact with water. The newer ones are claimed to be moisture resistant and suitable for placing on wet surfaces.

- **Other polymeric materials** that have been used in the past or are under development include acrylic concrete and furfuryl-alcohol-polymer concrete. Acrylic concrete has good bond strength, but requires dry aggregate, and can pose environmental and health hazards. Furfuryl-alcohol-polymer concrete was developed for rapid repair of bomb-damaged runways. It develops high early strength, and can be placed in wet conditions and at temperatures between -17°C and 52°C (-1 and 126°F). How this material would perform in highway repairs is not known. [17]

Bituminous Materials —

Bituminous concrete materials are sometimes used for partial-depth spall repairs of concrete pavements. However, they do deteriorate rapidly and are considered only temporary repairs.

CONSTRUCTION

Preliminary Quantity Estimation —

During plan, the design engineer should conduct a field survey. The objective of the survey is to mark approximate boundaries of areas requiring partial-depth repair to aid in the bidding process. Depending on how much time passes between the field survey and the start of construction, the actual extent of the deterioration may be greater than that shown on the plans. This is because spalling is progressive and areas of delamination can exist at the joints that have not yet spalled out. It is imperative that these areas also be repaired during construction. Therefore, it should be anticipated that the quantity of repair required could be greater than that originally estimated in the preliminary survey.

Marking Repair Boundaries —

Just prior to starting work, a preconstruction survey should be conducted to mark the actual repair boundaries. The survey should be conducted by the

Figure 5. Sounding the pavement with a chain.

Figure 6. Marking repair boundaries with spray paint.

Figure 7. Sawing repair boundaries

Figure 8. Chipping out the concrete within the repair area.

specifying agency and the contractor together. During the preconstruction survey, all areas of delamination should be identified using a sounding technique. Sounding is done by striking the concrete surface with a hammer, steel rod, or by dragging a chain (Figure 5) along the surface, and listening to the sound produced. A sharp metallic ring indicates areas where the concrete is sound, whereas a dull or hollow sound indicates areas where the concrete is delaminated. [10, 15, 19, 20]

Sounding should start along the pavement transverse joints or cracks and any midslab areas that exhibit visible spalling or severe scaling. If available, refer to the partial-depth patch locations shown in the plans for guidance, but do not rely on them completely. The conditions may be worse than when the engineers drafted the plans because of the continued spall deterioration.

To ensure that all unsound concrete is removed, the limits of the partial-depth repair should extend 100 mm (4 in.) beyond the delaminated or spalled area. [9, 15, 20] A square or rectangular boundary of the area to be removed should be marked with paint, as illustrated in Figure 6. Irregular shapes and internal corners may cause cracks to develop in the patch.

Areas less than 0.6 m (2 ft) apart should be combined into one repair area. Although this increases the quantity of repair material used, it expedites the construction process and improves the overall appearance of the partial-depth repair project.

Concrete Removal —

Spalled or delaminated concrete can be removed within the repair boundaries by sawing and chipping or milling.

Sawing and Chipping — To remove spalled or delaminated concrete by sawing and chipping, saw cuts are made around the perimeter of the repair area, as illustrated in Figure 7.

This provides vertical faces at the repair edges and sufficient depth to prevent spalling of the repair material along the repair perimeter. The saw cuts should be at least 25-50 mm (1-2 in.) deep. [9, 15, 19, 20, 21] The sawcut should slightly overrun the patch perimeter so that the bottom of the cut intersects the patch corner. Additional sawcuts are often made within the repair area to speed the removal of concrete by chipping.

The repair area should be chipped out to a depth of at least 35 mm (1.4 in.) with light pneumatic tools, less than 13 kg (30 lb.), as illustrated in Figure 8, until sound and clean concrete is exposed.

It is important that the proper tools be used. Using a pneumatic hammer that is too large will cause damage and fracture the concrete below the depth actually needed to reach sound material. [15, 19, 21] Jackhammers heavier than 13 kg (30 lb.) should not be used, because they may break through the slab completely. They may also cause microcracking which can weaken the bond between the existing concrete and the repair material.

For best results, use lighter, 7-kg (15 lb.) hammers. It is easier to control the depth of chipping with them. Operate the jackhammers and mechanical chipping tools at an angle of about 45°. This helps minimize the damage to the sound concrete. Finally, spade bits are preferable to gouge bits for control of chipping. Even light hammers with gouge bits can damage sound concrete. [9]

Removal near the repair boundaries must be completed with 5 to 7 kg (10 to 15 lb.) hammers and should continue until sound and clean concrete along the entire bottom of the repair area is exposed. [10] However, if the depth of the patch exceeds about one-third to one-half the slab thickness or exposes any dowel bars, switch to a full-depth repair.

Chipping—Spalled or delaminated concrete has also been removed by chipping without first sawing the patch boundaries. The deteriorated concrete in the center of the repair area is removed with a light jackhammer. The deteriorated concrete near the edges of the repair area is then removed using a light jackhammer and hand tools. The work should progress from the center of the repair area toward the edges, and the chisel point of the jackhammer should be directed toward the center of the repair area.[11]

Though chipping alone has been used, it is not recommended to use it without first sawing the patch perimeters. Past experience with partial-depth repairs constructed using chipping has shown that thin or feathered concrete along the repair perimeter is prone to spalling and debonding. [9, 15, 21]

Milling — Removal of the spalled or delaminated concrete by cold milling is especially efficient for pavements that need partial-depth spall repair across most or all of the full width of the transverse joints. A milling machine equipped with carbide-tipped bits is illustrated in Figure 9. The machine must be equipped with a device for stopping at a preset depth to prevent excessive concrete removal and possible damage to dowel bars or reinforcing steel.

Depending on the equipment and the lane closure scenario, milling may be done either longitudinally across the joint or transversely along the joint (Figure 10). Transverse milling is effective for spalling along an entire joint. Transverse milling produces more vertical boundaries, but can be a less efficient operation and can potentially interfere more with traffic move-

Figure 9. Removal of material within repair area using a cold-milling machine.

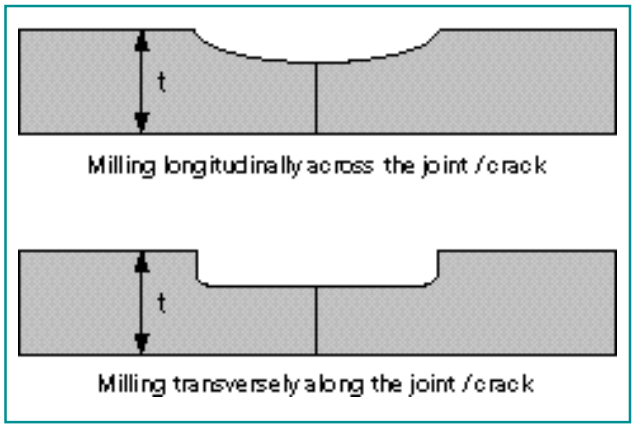


Figure 10. Profile of a partial-depth repair using milling equipment in removal.

ment in the adjacent lane. For small individual spalls, either milling direction is effective.

After milling, the bottom of the repair area should be checked by sounding to ensure that all unsound material has been removed. Any unsound material must be chipped out. If the depth of unsound concrete approaches or exceeds one-half of the slab thickness, place a full-depth repair.

Spalling has not been a problem with tapered edges produced by longitudinal milling. This is attributed to a gradual transfer of load through the repair material. The state of Minnesota has used both milling procedures very effectively.

Cleaning —

The exposed faces of the concrete should be thoroughly cleaned by abrasive blasting, such as sandblasting, to remove loose particles, oil, dust, and joint-sealant materials. These and any other contaminants interfere with bonding between the repair material and the existing concrete. Furthermore, the rough texture produced by abrasive blasting enhances bonding.

High-pressure water blasting is an alternative to abrasive blasting where controlling dust is critical in urban environments. Waterblast equipment for concrete removal should be capable of producing a blast pressure of 20-40 MPa (3000-6000 psi). However, to avoid damage, the equipment must be capable of adjustments that will allow removal of only weakened concrete.

All residue from abrasive blasting should be removed by airblasting just prior to placement of the bonding agent. The air compressor should deliver air at a minimum of 3.4 cu. m/min. (120 cu. ft/min.) and develop 0.63 MPa (90 psi) nozzle pressure. Even if the equipment has a filter, occasionally check the air for oil and moisture contamination. Oil sprayed onto the concrete will impede bonding of the repair material to the concrete. The equipment can be checked by placing a dry, clean cloth over the nozzle and blowing through the cloth. Any discoloration indicates moisture or oil residue.

Portable backpack blowers also are acceptable for removing dust and dirt from the repair area. However, air compressors with oil and moisture filters are preferred because of the higher pressure. Figure 11 shows a photo of a repair area being cleaned by airblasting just prior to placement of the patch.

Figure 11. Repair area being cleaned by sandblasting.

Joint Preparation —

Partial-depth repairs placed at longitudinal, transverse, or shoulder joints require special joint preparation work prior to placement of the repair material.

Joint Inserts — Partial-depth patches that cross or abut a working joint or crack require a compressible insert. The compressible insert reforms the joint or crack and makes a uniform face that is helpful when resealing. However, the most important function of the insert is to keep the adjacent concrete from bearing directly on the new patch. Bearing on the new patch has been the primary reason for failure of partial-depth repairs.

Bearing occurs in hot weather when the adjacent slab expands and pushes directly on the patch material instead of the full face of the joint. This is termed "point bearing." It causes the patch to fail by popout or delamination, as depicted in Figure 12. [9, 15, 20, 21] The joint insert eliminates point bearing by creating space for the slab to expand into.

Common compressible insert materials are Styrofoam or asphalt-impregnated fiberboard. [9] The insert width should match the width of the existing joint or crack. It should also be sized to extend about 25 mm (1 in.) below and 75 mm (3 in.) beyond each end of the patch area (Figures 13 and 14). An additional saw cut through the joint or crack may be necessary to allow the insert

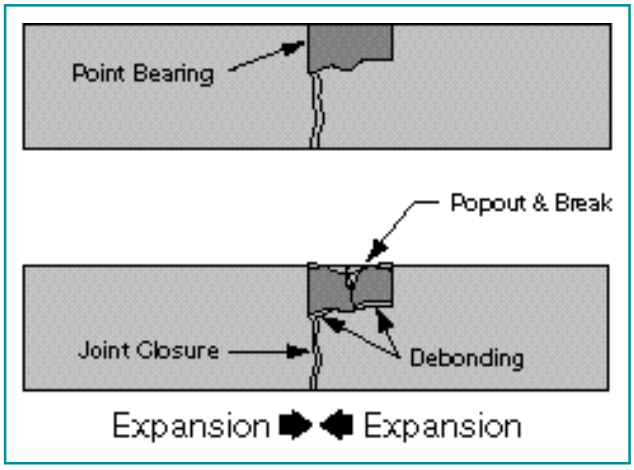


Figure 12. Popout of partial-depth repair due to point bearing.

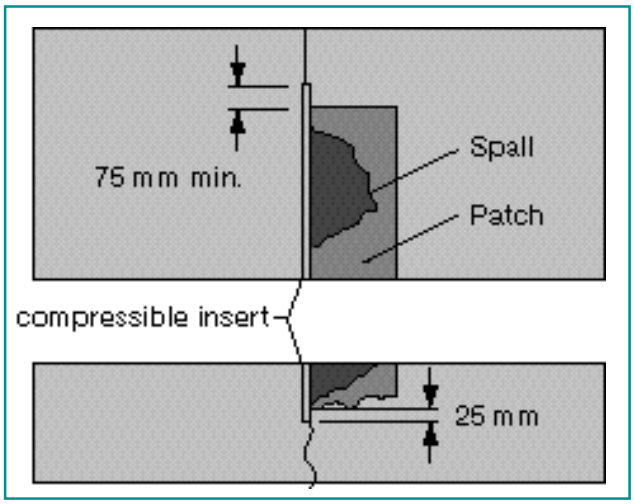


Figure 13. Recommended placement of compressible

Figure 14. Properly placed compressible insert.

to fit properly. If large gaps exist around the insert, either cut a new piece or fill the gaps with latex caulk.

At no time should the patch material be permitted to flow into or across the joint or crack. Bonding to the concrete in the adjacent lane or slabs will cause spalling of the repair.

When the repair material has hardened, the joint or crack reservoir may be reformed and resealed. In the case of transverse and longitudinal joints, this will often require sawing of a new joint sealant reservoir along the joint before new sealant is placed.

Shoulder Joint — If the shoulder is portland cement concrete, a compressible insert should be placed and sealed as previously described. However, if the shoulder is asphalt, special steps must be taken to insure that the repair material does not flow into the lane/shoulder joint or into the shoulder. If this happens, it may restrict longitudinal movement and result in damage to the repair or the shoulder. (15)

To place a partial-depth repair next to an asphalt shoulder, remove a small area of the asphalt shoulder surface adjacent to the repair material, and insert a thin piece of plywood or other insert in the lane/shoulder joint. This confines the repair material in the patch area so that it cannot flow into the lane/shoulder joint or into the shoulder. After the repair material has hardened, the plywood insert is removed and the asphalt surface is patched.

Material Placement —

The repair material should be placed as quickly as possible after preparing the patch area while the exposed concrete is clean and dry. It is a good idea to check the patch area for any dust or sandblasting residue before placing a bonding agent. Wiping the area while wearing a dark brown or black cotton glove will easily indicate a dust problem. Airblow again if the dust has settled back in the patch area.

Placing Bonding Agent — When placing the bonding agent or cementitious grout, apply the material in a thin even coat. The best results are obtained when the material is scrubbed into the surface with a stiff bristle brush. The material should cover the entire area including the patch walls and should overlap the pavement surface to ensure adequate bond.

Figure 15. Placing partial-depth repair materials.

Figure 16. Consolidation of partial-depth repair material.

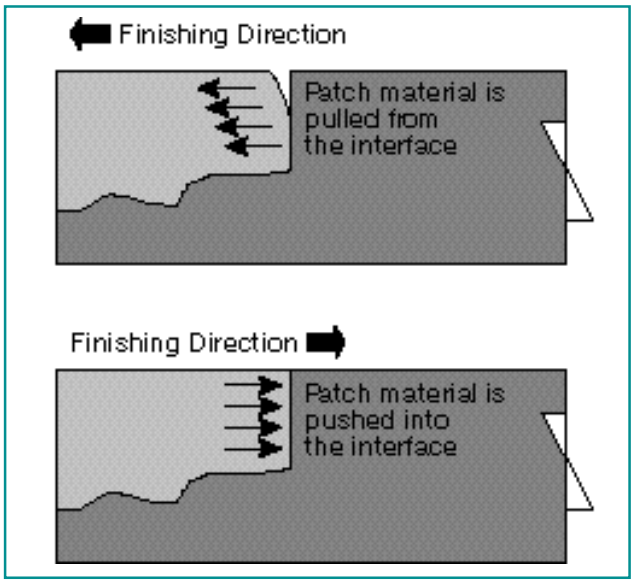


Figure 17. Effects of direction of finishing of repair material.

Cementitious grouts must not be allowed to dry before the repair material is placed.

Some partial-depth repair materials require epoxy or proprietary bonding agents. Epoxy bonding agents should be mixed carefully according to the manufacturer's instructions. Bonding agents and grouts should be mixed on site in small quantities.

Mixing — The volume of partial-depth repairs is typically very small. Therefore, partial-depth repair materials are usually mixed on site in small mobile drum or paddle mixers. On-site mixing avoids wasting material and may improve quality. If the quantity of patches is large, ready-mix trucks can speed placing operations.

Material Placement and Consolidation — Place concrete into the repair area from wheelbarrows, buggies, or other mobile batch vehicles (Figure 15). For small patches, shovel the patch material. Where the patch material is mixed in ready-mix trucks, direct the concrete into the patch area with the truck's chute.[9]

The repair area should be slightly overfilled to compensate for consolidation of the patch material. Once the repair material is placed, vibrate the fresh concrete with a small spud vibrator to remove entrapped air and eliminate any voids. This is especially important at the interface of the patch and existing concrete.

The vibrator should be held vertically and inserted into the repair material. The vibrator should not be dragged through the repair material, nor should it be used to move the repair material. These actions may cause segregation of the mix and loss of entrained air. Consolidation of a freshly placed partial-depth repair is illustrated in Figure 16. On very small repairs, hand tools should be sufficient to achieve adequate consolidation.

Finishing — The repair material should be finished flush with the surface of the existing concrete. It is recommended to finish the patch outward from the center of the repair toward the edges. This pushes the repair material into contact with the repair faces, rather than pulling it away, as illustrated in Figure 17. This technique provides a smooth transition and enhances the bond at the repair faces.

Texturing — The repair material should be textured in a manner similar to that of the surrounding concrete. However, because of the small size of partial-depth repairs, the surface texture will not have any significant effect on the overall friction characteristics of the pavement surface. Burlap drag, broom and transverse tine surfaces are common.

Sealing Patch Perimeter and Sawcut Run-outs — For cementitious repair materials, an important step of partial-depth repairs is sealing the repair/slab interfaces and saw cut run-outs, as illustrated in Figure 18. Sawcut run-outs are the sawcuts extending beyond the repair boundaries. They are made because sawing to the appropriate depth along the full repair boundary causes the blade to extend beyond the patch perimeters.

Figure 18. Sealing repair boundaries with cement-water grout.

Sealing is done with a thin 1:1 cement-water grout, which is painted along any repair edges that do not abut joints or cracks. The grout should cover the entire patch perimeter and fill the sawcut run-outs. The grout will form a moisture barrier over the perimeter and impede delamination of the repair. If water is able to infiltrate the interface along the repair perimeter, it can freeze and spall the repair.

Curing — Curing is very important because of the partial-depth repair's large surface-area-to-volume ratio makes them susceptible to rapid heat and moisture loss. Neglecting to cure the patches, or waiting too long to apply the compound, will likely result in excessive material shrinkage and possible patch delamination.

When using a cementitious repair material, a liquid membrane-forming curing compound that meets ASTM C 309 [22] material requirements is adequate. The compound creates a seal that limits mix water evaporation and contributes to thorough cement hydration. Some agencies specify a white-pigmented compound (Type 2, Class A) that is easy to see after application. Other agencies specify a resin-based curing compound that meets ASTM C 309, Type 2, Class B requirements and may not contain a white pigment, but can produce a more effective evaporation barrier. An application rate of about 5 sq. m/L (200 sq. ft/gal) is sufficient for either material. When specialty repair materials are used, curing should be done according to the manufacturer's recommendations.

Where early opening to traffic is required, it may be beneficial to place insulation mats over the repairs. This will hold in heat from hydration and accelerate strength gain in cementitious materials. To prevent moisture loss and to protect the surface, a layer of polyethylene sheeting should be placed on the patch surface under the insulation mats.

Insulation mats may not be necessary — and may cause cracking — in hot weather. The purpose of insulation is to aid early strength gain in cool temperatures. After removing the insulation, thermal shock may induce shrinkage cracks if the insulation retained excessive heat in the concrete.

Smoothness—

A good finishing technique can develop an adequate transition between the repair and the surrounding concrete. However, if the pavement contains many closely spaced repairs, it may be difficult to achieve acceptable surface smoothness. In these cases, consider specifying a ride quality comparable to the local ride standards for new concrete pavements. Repaired pavements that do not meet the specified ride requirement will require correction by diamond grinding. Grinding should precede joint sealing operations.

Joint Sealing—

After the repairs have gained sufficient strength, the joints should be resealed. Resealing should be done in accordance with the requirements of the specifying agency. It is important that the joint faces are clean

and dry for good sealant performance. Sawing, to provide the proper shape factor, and abrasive blasting, to remove dirt and saw laitance from the joint face, are essential. Resealing the joint is extremely important, because it will help prevent moisture and incompressibles from causing further damage. Figure 19 shows a completed patch after joint resealing. For more information on joint sealing, see ACPA publication *Joint and Crack Sealing and Repair for Concrete Pavements (TB012P)* [5].

Figure 19. Completed patch after joint resealing.

OPENING TO TRAFFIC-

There are two methods to determine when to open partial-depth repairs to traffic: [23]

- Specified minimum strength.
- Specified minimum time after completing placement.

For most concrete pavement applications, it is preferable to measure the concrete strength to determine when it is acceptable for traffic. This is not always true for concrete repairs, particularly where quick opening is not critical. Most repair mixtures fall into one of three categories for opening to traffic: 4 to 6 hours, 12 to 24 hours, and 24 to 72 hours (conventional). Contractors often use conventional mixtures in repairs on large projects, in low-traffic areas, or in other situations where quick opening is not necessary. For these situations, specifying a minimum time after placement is reasonable. [23]

For the 4- to 6- hour mixtures and 12- to 24- hour mixtures, a strength test using portable cylinder test devices, maturity meters, or pulse-velocity devices are preferable to a specified time requirement. [23]

PERFORMANCE

The key factors influencing the performance of partial-depth spall repairs are the appropriateness of their use, the quality of construction, and the behavior of the repair material.

Partial-depth repairs should only be used to repair surficial spalls that do not extend to more than one-third to one-half of the slab depth. Partial-depth repairs are not appropriate for some types of concrete deterioration such as D-cracking that are usually not confined only to the surface. Likewise, they should not be used if dowels or reinforcing steel are uncovered during construction.

Partial-depth repairs may be constructed successfully across working transverse joints or cracks, but they will crack and fail if the joint or crack is not reestablished through the repair. Finally, partial-depth repairs may perform well but may not be cost effective for a pavement that has little or no remaining structural life and will soon need resurfacing or reconstruction.

The performance of partial-depth repairs is highly dependent on the quality of the construction operations. The construction steps described in this bulletin are those used by several agencies that have had several years of good experience with partial-depth repairs.

Performance reviews of various partial-depth spall repair materials typically have compared the performance of conventional Type I or III cement-based patch materials with proprietary materials. In most cases the conventional concrete mixtures have performed as well or better than most of the proprietary mixtures and specialty blends. [17]

ADDITIONAL INFORMATION

Additional information on partial-depth repair can be obtained by contacting the American Concrete Pavement Association.

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