Concrete: Partial Depth Repair

An Online Continuing Education Course for Engineers

Course Number: C-1024

Credit: 1 Hour / 1 PDH / 1 CPD

Concrete: Partial-Depth Repair

1.0 Introduction

Partial-depth repair (PDR) is a concrete pavement restoration technique that corrects localized distress such as spalls, scaling, and popouts in concrete pavements. PDR restores structural integrity and utility of the pavement, and prevents further deterioration, thus extending the pavements service life. Also, partial depth repairs are required to prepare an existing, distressed pavement prior to a structural overlay or restoration project.

PDR involves removing an area of deteriorated concrete that is limited to the top one-third of the slab thickness and replacing it with appropriate repair materials. Depending on the type of repair material used and the repair location, a new joint sealant system may be placed as well. The repair technique can be applied either transversely or longitudinally on the pavement where deteriorations are detected. When applied at appropriate locations, PDR can be more cost effective than full-depth repair. The cost of PDR is largely dependent upon the size, number, and location of repair areas, as well as the materials used. Lane closure time and traffic volume also affect production rates and costs.

2.0 Selection of Candidate Projects

2.1 Pavement Condition

Partial depth repair restores localized surface distresses of concrete pavement within the upper one-third of the slab. It replaces small, deteriorated areas with suitable repair materials. PDR is commonly used to repair low-severity spalling within 6” of the joint and less than 2” deep, but can also be used for low-severity scaling & popouts. If PDRs are being considered, coring should be performed at representative joints to determine the depth of deterioration.

PDR is <u>not</u> appropriate for the following pavement conditions; rather, FULL-depth repair should be considered:

- Cracks extending through the full slab thickness
- Spalls that extend more than 6 to 10” from the joint
- Spalls beyond the top one-third of the slab caused by misaligned dowel bars, D-cracking, or alkali-silica reactivity (ASR)
- Spalls that expose reinforcing steel or dowels
- Pavements that will be cracked and seated, broken and seated, or rubberized prior to overlay

2.2 Climatic Conditions

The wetter and colder the climate, the greater the need for timely PDR. However, spalling can occur in any climate, and proper partial-depth spall repair will help reduce further deterioration. The damage caused by freezing and thawing cycles is a serious problem in jointed Portland cement concrete (PCC). In wet and freezing climates, the continued presence of water on and in the pavement and the use of deicing salts often worsens the damages.

Even in non-freezing climates, any moisture in the concrete can cause corrosion of reinforcing steel in the pavement. Corroding steel creates expansive forces that can lead to cracking, spalling, and debonding of the concrete around it. Reinforcing steel without enough concrete cover is even more likely to corrode. Timely PDR can protect high reinforcing steel that has not yet corroded and can prevent more serious spalling.

Spalling may also occur in dry and freezing climates. Incompressible solids that are trapped in a joint when the adjacent slabs contract during freezing create high compressive stresses in the joint face when the pavements expand during thawing. Early repair of nonfunctioning joint sealing systems, along with any adjacent spalling, can protect the joint from further deterioration.

3.0 Design Considerations

PDR extends the life of PCC pavements by restoring ride quality to pavements that have spalled joints. PDR of spalled areas also restores a well defined, uniform joint or crack sealant reservoir prior to joint or crack resealing. When properly placed with durable materials, these repairs can perform well for many years. The following factors should be considered during the design of PDRs.

3.1 Objective of Partial-depth repair

PDRs may have several objectives. In adverse conditions, a temporary PDR may be needed. In this case, the design should provide for adequate temporary repair life until a permanent repair can be made.

If performing PDR prior to an overlay construction, tolerances are not as stringent. For example, repair edges do not have to be completely vertical and straight, the repair material does not need to wear well, and the joint does not have to be sealed. This is because the overly will reduce the load and environmental stresses on the repair. Furthermore, an overlaid repair material will experience smaller temperature changes than a repair that is not overlaid.

If a spall must be repaired because it presents a hazard to the highway user, but the pavement is scheduled for an upcoming rehabilitation that will destroy the repair, design considerations should reflect this anticipated short service life.

PDR that will not be covered or destroyed in a future rehabilitation will be exposed to traffic and climate for a long time. In this case, it is cost-effective to select high quality materials, repair methods, and workmanship.

3.2 Selection of Repair Boundary

An important step in constructing a successful PDR is the identification and removal of all deteriorated concrete. The actual extent of the deterioration in the concrete may be greater than is visible at the surface. In the early stages of spall formation, weakened planes often exist in the pavement with no sign of deterioration visible at the surface. Refer to Section 4.2 for more details.

3.3 Selection of Materials

Material selection for PDR should consider the following factors: mixing time and required equipment, working time, temperature range for placement, curing time, aggregate requirements, repair area moisture conditions, cost, repair size, and bonding requirements.

3.3.1 Cement Materials

3.3.1.1 Normal Concrete Mixtures

- Portland cement type I, II, or III is typically used for partial depth repairs.
- Normal set concrete can be used when the repair material can be protected from traffic for more than 24 hours.
- Normal set concrete should NOT be used when the air temperature is below 40° F (4° C). At temperature below 55° F (13° C), a longer curing period or insulation may be required.
- Size of coarse aggregate must not exceed half the minimum repair thickness.
- Type I cement is popular because of its relatively low cost, availability, and ease of use.
- Type III cement or an accelerated repairs admixture is used for repairs that need to be opened to traffic quickly. An insulating layer can be placed on the hydrating PCC to retain the heat of hydration thereby increasing the rate of strength development.

3.3.1.2 Specialty Cement Mixtures

- Gypsum-based (calcium sulfate) repair materials, such as Duracal and Rockite, can be used in any temperature above freezing or for rapid strength gain. However, gypsum concrete does not perform well when exposed to moisture or freezing weather, and the presence of free sulfates in the typical gypsum mixture may be promote steel corrosion in reinforced PCC.
- Magnesium phosphate cement mixtures are characterized by a high early strength, low-permeability, and good bonding to clean dry surfaces. However, they are extremely sensitive to water content and aggregate type (especially limestone); very small amounts of excess water can significantly reduce strength.

- High alumina cement mixtures produces a rapid strength gain concrete with good bonding properties (to dry surfaces) and very low shrinkage. However, they should not be used because a significant strength loss is likely to occur due to chemical conversions in the calcium aluminate cement during curing.
- Accelerating admixtures/additives may achieve high early strengths and reduce the time to opening. Premature deterioration can be developed due to insufficient curing time. Some states prohibit calcium chloride (CaCl2) accelerators due to problems with excessive shrinkage and dowel corrosion.
- Alumina powder may be used as an admixture with Type I, Type II, or Type III cement to counteract shrinkage. However, the reactivity of aluminum powder can be difficult to control in field proportioning, particularly in small batch operations. The use of alumina powder may also decrease the bond strength and patch abrasion resistance.

3.3.2 Polymer Materials

Polymer concretes are characterized by their quick set in comparison to normal concretes. They are both more expensive and quite sensitive to certain field conditions, such as temperature range. Polymer concretes are a combination of polymer resin, aggregate, and a set initiator. They are categorized by the type of resin used: epoxies, methacrylates, polyester-styrenes, and urethanes.

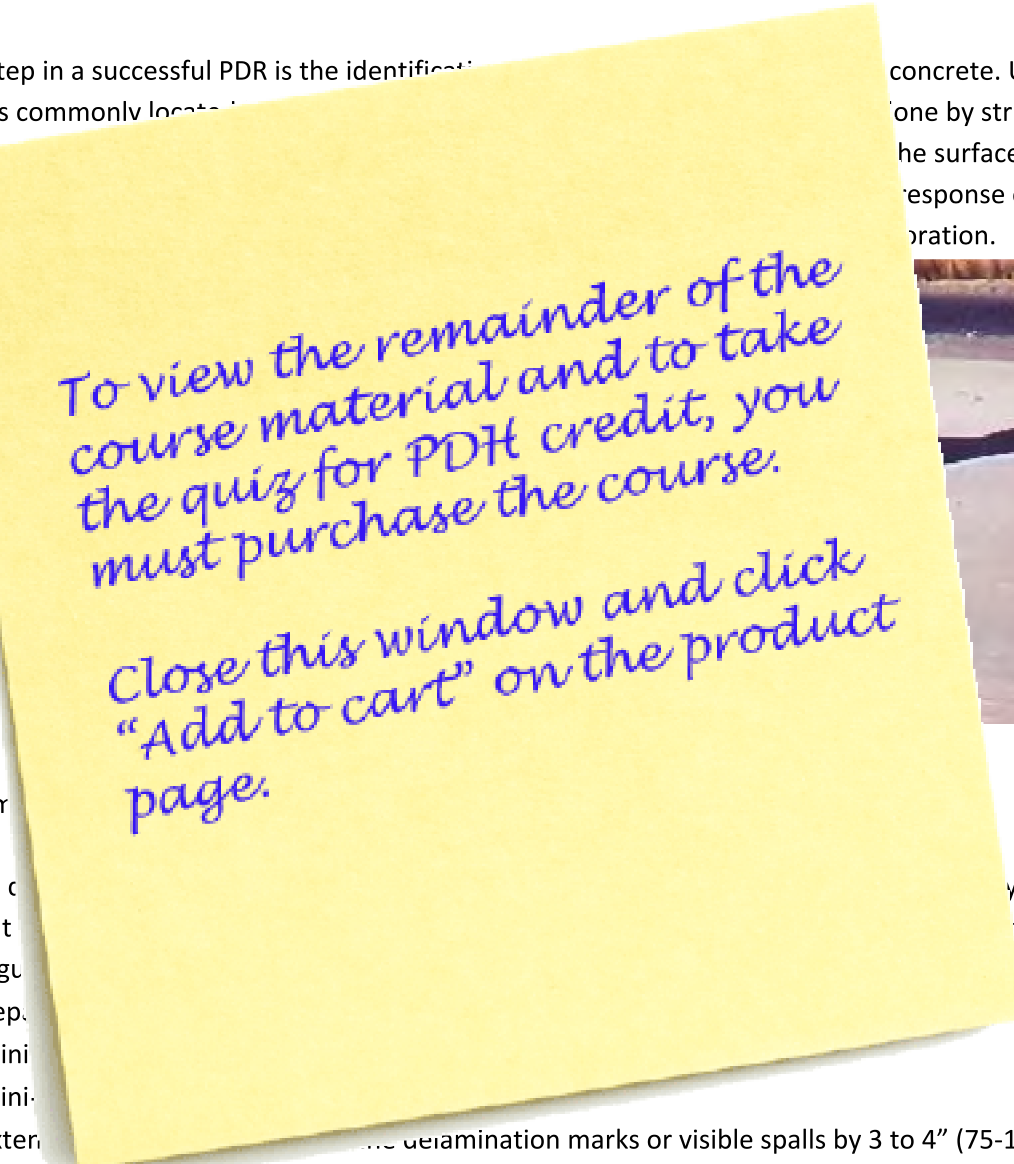
- Epoxy mixtures have excellent adhesive properties and low permeability. However, they are not thermally compatible with normal concrete, sometimes resulting in early repair failure. The use of larger aggregate can improve their thermal compatibility with concrete and reduce the risk of debonding. Epoxies are available with a wide variety of setting times, placement temperature ranges, strengths, bonding capabilities, and abrasion resistance properties. The selection of a particular epoxy mixture should be based on the project's environmental conditions and construction constraints. Epoxy concrete should not be used to repair spalls caused by reinforced steel because it can accelerate the corrosion of the steel in the adjacent, unrepaired concrete by creating a highly cathodic area.
- Methyl methacrylate concretes have relatively long working times (30-60 minutes); high compressive strengths; good adhesion to clean, dry concrete; and a wide placement temperature range between 40 and 130 °F (5 - 55 °C). But many of them produce fumes, which are a health hazard and can ignite if exposed to a spark or flame.
- Polyester-styrene concrete has very similar properties to methyl methacrylate concrete, but posses a much slower rate of strength gain. This limits its usefulness for PDR.
- Polyurethane concrete consists of a two-part polyurethane resin mixed with aggregate. They set very quickly (~90 seconds). Two types are available: the older type which is moisture sensitive and will foam in contact with water; and the newer ones which claim to be moisture tolerant and can be placed on wet surfaces.

4.0 Construction

With good design and construction practices, PDR should last as long as the surrounding concrete pavement. The most frequent causes of performance problems are related to misuse of the technique, poor repair material, and careless installation.

4.1 Find Deteriorated Concrete

The first step in a successful PDR is the identifi... concrete. Unsound concrete is commonly loc... one by striking the conc... he surface. The rod, ham... esponse on deter... ration.



4.2 Determ...

Include all ... y-colored spray paint ... e the following gu...

- Rep...
- Mini...
- Mini...
- Exter... delamination marks or visible spalls by 3 to 4" (75-100 mm)
- Do not re... a spall that is less than 6" (150 mm) long and less than 1.5" (35 mm) wide
- Combine repairs less than 12" (300 mm) from each other
- Repair the entire joint length if there are more than two spalls along a transverse joint