Deck Preservation: Sealers, Overlays and Patching

The deck is the bridge component that takes the most abuse and usually needs the most maintenance. Most deck deterioration comes from one chain of events: water and chlorides get into the concrete through cracks and pores, reach the reinforcement, and corrode it, and the corrosion products crack and delaminate the cover. Deck preservation means breaking that chain early, with washing, penetrating sealers, crack sealers, thin and thick overlays, and well-built patches, matched to the deck's condition. This course covers how to choose and sequence those treatments. It draws on the FHWA Bridge Preservation Guide (FHWA-HIF-18-022, 2018), Chapter 7 of the Florida DOT Bridge Maintenance Course Series Reference Manual (Maintenance and Preservation Techniques for Bridge Decks and Slabs), and Chapter 2 of the TxDOT Bridge Preservation Guide (March 2024). Product properties, service lives and costs quoted from those documents reflect those agencies' experience. Numbers in worked examples that do not come from these documents are labeled illustrative.

Learning objectives

- Select penetrating sealers and crack sealers
- Compare overlay types
- Plan deck patching
- Time treatments by condition

Why decks need their own preservation strategy

The FDOT Bridge Maintenance reference manual compares the deck to the roof of a house: it "receives the brunt of the storm and shelters the contents below from the harsh elements." Decks are worn by traffic deflection and tires and exposed to rain, snow and ice, so they "typically require more maintenance and repair than any other bridge component."

Durability begins in design and construction. FDOT lists design features that improve it: adequate cover over the reinforcement, good drainage, smaller skews and thicker slabs. It lists material and construction practices too: achieving the specified cover, air-entrained concrete where there is freezing, appropriate water-cement ratios, good consolidation, and proper curing that prevents excessive shrinkage cracking. A preservation program inherits whatever the original construction delivered; it cannot add cover that was never placed. What it can do is slow the next stage.

The corrosion chain

FDOT states that the main cause of concrete deck deterioration is corrosion of the reinforcing steel. Small cracks give water and chlorides a path to the steel. Once the steel corrodes, the corrosion products expand and cause delaminations and spalls. The problem is worst where deicing salts are used. FDOT's conclusion is the organizing idea of this course: "To slow the corrosion cycle, the water and chlorides must be kept from reaching the reinforcing steel." It continues that sealing deck cracks and overlaying the surface with dense materials slow deterioration by limiting the water and salts that reach the steel, and that if a significant amount of chloride has already reached the steel, cathodic protection may be used to stop corrosion from progressing.

Every treatment in this course fits somewhere on that chain:

- **Remove the chlorides at the surface** before they soak in: washing.
- **Make the surface repel water** or block pores: penetrating sealers.

- **Close the cracks**, which are the express lanes to the steel: crack sealers, flood coats and injection.
- **Add a dense barrier** over the whole surface: thin polymer overlays, asphalt with membrane, and rigid concrete overlays.
- **Remove what has already failed** and rebuild it: partial- and full-depth patching.
- **Interrupt corrosion electrically** where chlorides are already at the steel: galvanic anodes and cathodic protection.

How the FHWA Guide classifies deck work

The FHWA Bridge Preservation Guide places most of this work in preservation. Its Table 2 lists cyclical activities including cleaning and washing, cleaning and flushing drains, cleaning joints, and "deck/parapet/rail sealing and crack sealing." Its Table 3 lists condition-based deck activities including drain and joint work, electrochemical chloride extraction (ECE) or cathodic protection (CP), "concrete deck repair (see halo effect below) in conjunction with overlays, CP systems or ECE treatment," and deck overlays (thin polymer epoxy, asphalt with waterproof membrane, rigid overlays). Its Table 1 lists "asphalt patch with no membrane on concrete deck" as routine maintenance with no preservation value and no federal eligibility. Partial or complete deck replacement is rehabilitation. BR-DP01 covers those definitions and their funding consequences; this course covers the treatments themselves.

Where this course fits

BR-DP01 (Bridge Preservation Programs) sets up the program framework. BR-C01 (Concrete Deterioration Mechanisms) explains corrosion, freeze-thaw and alkali-silica reaction in more depth, and BR-C02 (Concrete Repair Methods) covers repair materials and techniques that apply to decks and other members. BR-I06 (Concrete Element Inspection) and BR-N01 (NDE for Concrete) cover how the deck data in this course are gathered. BR-B02 (Deck Joints) covers the joints that sit in the deck and so often dictate where it fails first.

Assessing the deck before choosing a treatment

The right treatment depends on what is happening inside the deck, not only on the surface. The TxDOT Bridge Preservation Guide describes the assessment tools in order of increasing effort, and cautions that travel disruption and cost should be weighed against the value of each technique. For decks with clear visual signs of widespread advanced deterioration, advanced methods such as ground penetrating radar (GPR), half-cell potential and coring "are generally not necessary": the answer is already visible.

Visual observation

TxDOT says that observations from a moving vehicle "are not sufficient to detect small cracks on the deck"; the preferred practice is to walk the bridge, and to examine both top and bottom surfaces. Transverse cracks are common and may come from material issues, insufficient curing or other construction issues, or environmental issues; transverse cracking alone is generally not a structural concern, but unaddressed cracks shorten service life through corrosion. Map pattern cracking (closely spaced intersecting transverse and longitudinal cracks) and previous repairs, asphalt or concrete patches, are indicators of more advanced deterioration. TxDOT warns that this kind of cracking "may eventually lead to punch-through failure."

Sounding

Hammer sounding, chain drag or electromechanical sounding locates delaminations, which produce a lower-pitched sound than the ringing of sound concrete. TxDOT notes an ASTM standard practice exists (D4580), that little experience is needed,

and that an effective chain drag can be built inexpensively. Use the chain drag to survey large areas and the hammer to define boundaries. Sound near the boundaries of previous repairs, where new delaminations often form. Traffic noise can interfere, so repeat as needed. FDOT also lists chaining, impact echo and GPR among methods for locating delaminations.

Impact echo, infrared and GPR

TxDOT describes impact echo as more sensitive than sounding and able to detect delamination at an earlier age, but slow and requiring expertise; it cannot be used on decks with asphalt overlays. Infrared thermography can detect delamination when deck temperatures are rising or falling rapidly; its window is limited, it cannot be used through asphalt overlays, but it can verify chain drag findings. GPR is good for measuring cover to the top bar and can identify regions more conducive to corrosion, but TxDOT reports it has not identified active corrosion, and that air-coupled GPR has not reliably predicted delamination in Texas. BR-N01 covers these methods in detail.

Half-cell potential and resistivity

Half-cell potential (HCP) measures the voltage between a reference electrode and an exposed, electrically continuous bar. TxDOT reproduces the ASTM C876 interpretation for a copper/copper sulfate electrode:

Half-cell potential (mV, Cu/CuSO4)	Likelihood of corrosion (as tabulated by TxDOT)
Less than -500	Visible evidence of corrosion
-350 to -500	95%
-200 to -350	50%
Greater than -200	5%

HCP cannot measure the degree of corrosion, needs bar continuity, and is limited to decks without overlays and without epoxy-coated reinforcement. Surface resistivity needs no bar connection and can screen areas quickly; lower resistivity means higher corrosion risk, and TxDOT notes it is often agreed that risk is negligible above 100 kΩ-cm.

Chloride coring

Coring is destructive and TxDOT approves it case by case, noting that recent coring "has only confirmed the high chloride content expected based on visual distress." Where it is done, the thresholds matter for treatment choice. TxDOT gives a generally accepted corrosion threshold for unprotected reinforcement of about 1.2 to 1.5 lb of water-soluble chloride per cubic yard, and a suggested threshold for epoxy-coated bars of about 4.5 lb/cy, while noting that intact steel has been found above these levels. Test water-soluble rather than acid-soluble chloride, since acid-soluble results include chloride bound in aggregate that does not drive corrosion. Most usefully for preservation timing, TxDOT states that when chloride at the top bar level reaches half the threshold, "an impervious deck overlay may be installed to slow down chloride penetration."

That rule captures the logic of the whole course. Sealers and overlays are most valuable before chlorides reach the steel. Once they have, a barrier on top slows the supply but does not stop corrosion already under way; that is when patching, anodes or CP enter the plan.

Washing and cleaning

Washing is the simplest deck preservation action and the one an agency is most likely to skip. FDOT describes it as "a proactive corrosion protection method" that floods the deck to rinse away or dilute dirt and chlorides, lowering the chloride

concentration at the surface. It adds that regular flushing can reduce chloride levels in the concrete and improve air circulation and drying, and that local environmental rules on collecting wash water must be understood before washing.

The TxDOT guide states the purpose directly: washing removes residual chlorides from winter deicing salts that would otherwise cause corrosion, and chloride-laden runoff through leaking joints can damage steel bearings and bent caps. It says washing to remove sand and debris may be done annually in the spring, depending on the severity of the winter, and should cover the approach slab, deck, curbs and between rail faces, followed by thorough flushing. It names three types of mechanical washing, including power washing (low pressure, flow more than a hundred gallons per minute) and pressure washing (at least 1,750 psi at 3.5 gallons per minute).

The FHWA Guide lists cleaning and washing and cleaning and flushing drains as cyclical preservation (Table 2), and its example cyclical rule for decks rated 7 or higher calls for sweeping and washing every 1 to 2 years (Table 5). It recommends that an agency starting a program begin with cleaning, using brooms and shovels and then hoses or pressure washers.

Practical points

- **Timing.** Wash after the deicing season ends, before spring rains carry the remaining salt into cracks.
- **Sequence.** Remove dry debris first, then flush from the high side to the low side and toward drains.
- **Drains and joints.** Clear scuppers and downspouts so the wash water and future rain leave the deck. Flush joint troughs and seats under joints; the beam ends there are often the most corroded steel on the bridge (BR-B02).
- **Records.** Record the date and extent of washing for each bridge so the program can tell whether it is happening.

Penetrating sealers

Sealers keep water and chloride out of sound concrete. FDOT divides waterproofing treatments into two general classes. **Penetrating sealers**, which include silanes, siloxanes and high molecular weight methacrylate (HMWM), "penetrate surface cracks and voids in the concrete and limit the penetration of water and salts without leaving a film on the surface." **Film formers**, which include epoxy healer-sealers, methacrylates and polyurethanes, produce a thin film over the surface. A thin epoxy overlay both penetrates and forms a film. FDOT says these treatments are typically applied to decks that are new or in good overall condition, as a preventive treatment.

FDOT's Table 7.2 summarizes typical thicknesses:

Sealer type	Type	Thickness
Silane	Penetrating	0
Siloxane	Penetrating	0
HMWM	Penetrating	0
Epoxy healer-sealer	Penetrating/film former	3 to 10 mils
Thin epoxy overlay	Film former	250 to 375 mils
Methacrylate	Penetrating/film former	20 to 30 mils
Polyurethanes	Film former	3 to 5 mils

Silane

The TxDOT guide treats silane under its Item 483, Penetrating Concrete Surface Treatment. It applies to existing decks "that have minor cracking or scaling, not otherwise overlaid." It "does not provide a structural benefit"; it seals the deck against external moisture and contaminants. Surface preparation is shot or abrasive blasting to remove oils and contaminants, and any concrete deck repair must be done at least 7 days before the treatment. TxDOT gives a cost of about $10 per square yard (2020) and an anticipated life of 5 to 10 years when properly installed. It notes candidly that "many of the problems associated with silane treatments stem from poor application and an inability to properly test for proper application." TxDOT also discontinued silane on new high performance concrete decks, on the assumption that HPC's low permeability makes extra sealing unnecessary.

FDOT's Table 7.4 lists silane/siloxane for "waterproofing good condition concrete," with viscosity below 1 centipoise, a minimum cure of 1 to 4 hours, the original surface providing skid resistance, and an expected useful life of 3 to 5 years.

Reading the life ranges

The two agencies' service lives for silane differ (3 to 5 years in the FDOT table, 5 to 10 in the TxDOT guide), and the FHWA Guide's example cyclical rule uses a 3 to 5 year deck sealing interval. The differences reflect climate, traffic, product and how life is defined. The lesson for a program is the FHWA Guide's: set an interval, then use inspection data to "update intervals for scheduled replacement" of surface sealers.

Application principles

FDOT's manual gives a step-by-step procedure for applying penetrating deck sealers, illustrated with shot abrading, application and sand broadcast. The principles that recur across the FDOT and TxDOT documents are:

- **Clean, open surface.** Shot or abrasive blasting removes oils, curing compound and laitance that would block penetration.
- **Repairs first.** TxDOT requires repairs at least 7 days before sealing, so the patches are cured and the sealer covers them.
- **Follow the product data.** Moisture, temperature and coverage rate determine whether a penetrating sealer actually penetrates.
- **Verify.** Because a penetrating sealer leaves no film, a properly treated deck looks the same as an untreated one. Specify a way to confirm coverage, such as recorded application rates and quantities used per area.

Crack sealing: penetrating crack sealers, flood coats and injection

Cracks are the shortest path to the reinforcement, so closing them is one of the highest-value deck actions. FDOT distinguishes widespread cracking, best treated with penetrating sealers spread over the whole area, from larger discrete cracks, best treated with pressure injection. Sealing either kind "will reduce the water and chlorides that are able to reach the reinforcing layer."

Gravity-fed crack sealers

FDOT explains that penetrating crack sealers are sprayed or poured on the deck and spread with brooms or squeegees. They have low viscosity, which lets capillary action draw them into cracks. FDOT gives comparative viscosities: water about 1 centipoise, methacrylates about 10, epoxy-based healer-sealers about 80, and epoxy thin overlays typically about 1,500 (similar to honey or heavy motor oil). On curing, the sealer bonds to the crack walls and "significantly reduce[s] the

permeability of the concrete." Selection depends on crack width, available cure time and the desired flexibility of the cured product.

The TxDOT guide calls this a flood coat or gravity-fed sealant (epoxy or methacrylate). Its primary use is "extensive shallow bridge deck cracking (5 to 10% of deck surface)." It is recommended on decks without delamination, and may be used on decks with isolated delamination after partial- or full-depth repairs, done at least 7 days before sealing. Fine sand is broadcast onto the wet resin, which can improve skid resistance, though TxDOT calls that sand cover "sacrificial/temporary." Surface preparation is shot or abrasive blasting. TxDOT says the treatment "can be expected to seal deck cracking and delay chloride contamination and corrosion for approximately 5 years when installed properly." Like silane, it provides no structural benefit.

Comparing crack sealers

FDOT's Table 7.4 compares options (asterisked: sealers should be formulated specifically for the cracks being addressed):

Attribute	Silane/siloxane	Heavy weight methyl methacrylate, polyurethanes	Epoxy healer-sealer	Thin epoxy overlay	Injection epoxy
Typical application	Waterproofing good condition concrete	Crack sealer for widespread fine cracking	Crack sealer for widespread fine cracking	Crack sealer for widespread, discrete, larger crack widths	Crack sealer for widespread, discrete, larger crack widths
Viscosity (cP)	<1	20 to 200	50 to 150	1,500 to 3,000	500 to 2,000
Pot life (min)	NA	5 to 45	20 to 60	15 to 30	15 to 30
Minimum cure (hr)	1 to 4	2 to 12	3	1	2
Skid resistance	Original surface	Broadcast fine aggregate (sand)	Broadcast sand	Broadcast sand	Broadcast sand
Expected useful life (yr)	3 to 5	5 to 10	5 to 10	10 to 15	5 to 10

The pattern is worth remembering: viscosity rises from left to right. The thinnest materials penetrate the finest cracks and pores; the thicker ones bridge wider cracks and build a wearing film. The longest expected life in the table belongs to the thin epoxy overlay, which is also the only one that forms a true wearing surface.

Injection of discrete cracks

For discrete or localized cracks, FDOT describes sealing or injecting epoxy or other polymers to fill the void and re-bond the faces. Citing ACI RAP Bulletin 1, it says epoxy injection can restore structural integrity and reduce moisture penetration through cracks 0.002 in. wide and greater. Full-depth cracks must be capped top and bottom before they are pressure injected from the top; caps have been made with epoxies, polyesters, paraffin wax and silicone caulk, and the cap material is chosen for non-sag consistency (overhead), moisture tolerance, working life and rigidity.

Working cracks

A crack that opens and closes under traffic will break a rigid epoxy bond. FDOT says a flexible elastomeric sealer may be warranted and lists signs of a working crack: it is open and shows evidence of movement; it has been sealed before and failed again; or concrete dust fills it. The injected material should be designed for the anticipated movement. TxDOT's preservation

matrix separates shrinkage and thermal cracks (its Type E) from significant cracks caused by overloading, structural design or substructure movement (Type F). The second kind is a structural question first: sealing it without understanding why it formed treats the symptom.

Overlays: the three families

An overlay replaces the deck's exposed surface with a new wearing layer. FDOT notes the trade-off at the start: wearing surfaces protect the deck "but also add dead load weight to the bridge and thus reduce the live load capacity." Adding a new wearing surface or thickening an existing one "should be evaluated by an engineer for impact on the live load capacity." BR-L01 and BR-L04 cover how added dead load enters a rating. FDOT groups overlays into asphalt, concrete and polymer.

FDOT's Table 7.5 compares them:

Attribute	Asphalts	Concretes	Polymers
Typical application	Thick flexible wearing surface over all common deck materials, with membrane	Durable thicker rigid wearing surface and deck protection	Thinner, more flexible deck protection and wearing surface
Typical thickness (in.)	1.5 to 6	1 to 5	0.5 to 1.5
Surface prep	Clean and milled or roughened	Steel shot, ground or roughened	Steel shot, ground or roughened
Minimum cure time for traffic (hr)	1 to 4	2 to 12	2 to 16
Skid resistance	Original surface	Concrete finish, grind or grooving	Broadcast fine aggregate (sand)
Expected useful life (yr)	15 to 20	15 to 30	10 to 20

FDOT points to ICRI Technical Guideline 310.2R-2013 (Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair) for surface preparation detail.

Asphalt with a waterproofing membrane

FDOT says asphalt overlays are common because they are easy to install, relatively inexpensive and familiar. But asphalt "does tend to trap and hold moisture and chlorides that can lead to deterioration of the underlying deck if not properly protected." Good practice is to include a waterproofing membrane under the asphalt unless the asphalt is a temporary ride-quality measure on a deck already planned for rehabilitation or replacement. Membranes are constructed in place (bituminous, spray-applied resins) or preformed (asphalt-impregnated fabrics, polymer, elastomeric, asphalt-laminated board). The most common are bituminous and asphalt-impregnated fabric; both use a tack coat on the prepared deck, the membrane, a protective board, another tack coat and then the asphalt. FDOT also describes the alternative of polymer modified asphalt (PMA) paved without a membrane because of its low permeability.

TxDOT, in a warmer state with its own experience, says asphalt overlays "are generally not recommended in Texas" because they are permeable and can trap chlorides and moisture against the deck, though some have performed well, especially at low traffic volumes. Where asphalt is specified over existing asphalt, TxDOT requires milling to avoid excessive thickness, and estimates a 10 to 15 year life depending on traffic. The FHWA Guide's distinction is the one to remember: an asphalt overlay with a waterproof membrane is condition-based preservation; an asphalt patch with no membrane on a concrete deck is

routine maintenance with no preservation value. Asphalt also blinds inspection: TxDOT notes impact echo and infrared cannot be used through it, and HCP needs it removed locally.

Rigid concrete overlays

FDOT lists high performance, latex modified, silica fume, fly ash modified and polymer concretes, and notes that several states have reported bonding issues with silica fume concrete, particularly in patching. Concrete overlays stiffen the deck, add cover over the reinforcement and reduce permeability. They also allow patching and overlaying "in a monolithic placement," which can improve ride.

TxDOT's concrete overlay (CO) applies to decks with minor to moderate cracking and partial- and full-depth repairs, and "can provide structural value with or without added reinforcing steel or steel fibers." A minimum thickness of 2 in. is desirable; steel fibers at about 40 lb/cy have generally been used. Preparation is shot blasting or milling with hydrodemolition, and the deck must reach a saturated surface dry (SSD) condition, for example by water blasting at a minimum of 4,000 psi for at least 15 minutes and then air cleaning standing water. CO needs 8 to 10 days of curing depending on the mix. TxDOT gives a cost of about $105/sy, more than 20 years of service, and notes hydrodemolition can add up to $100/sy. Its latex-modified concrete overlay (LMCO) is similar, for decks with moderate cracking, about $125/sy plus hydrodemolition, with up to 20+ years of service.

TxDOT gives two detailing cautions for both: these overlays "can spall along longitudinal construction joints within wheel paths and at acute corners," so phase joints should not fall in a wheel path, and details should include a breakback to avoid acute corners at skews over 15 degrees. Localized delamination between the overlay and the deck can be epoxy injected along the interface.

Thin polymer overlays

FDOT describes thin bonded polymer overlays as very common because they are light, cause minimal grade change, reduce permeability, and let the bridge return to service quickly. They are typically less than half an inch thick, applied in one or more layers, with epoxy, epoxy urethane or methyl methacrylate resins. The FHWA Guide lists thin polymer epoxy overlays among condition-based deck actions and uses 8 to 12 years for a polymer overlay in its example cyclical rule.

TxDOT calls the multi-layer version a multi-layer polymer overlay (MLPO). It applies to decks not otherwise overlaid, provides no structural benefit, but can seal extensive cracking, improve skid values and delay chloride penetration. Repairs must be done at least 7 days before. Preparation removes any asphalt, then shot blasts to at least ICRI CSP-5 roughness. Traffic must stay off the blasted surface before placement. TxDOT estimates a 15 to 20 year life, with quick return to service and a thin profile that avoids approach work. FDOT's illustrated sequence is shot blasting, mixing two-part epoxy, pouring, spreading with notched squeegees, broadcasting aggregate, and sweeping loose aggregate before opening.

Polyester polymer concrete

TxDOT also uses polyester polymer concrete (PPC) overlays, 3/4 in. minimum to 3 in. maximum, on decks not otherwise overlaid. After shot blasting and pull-off testing, an HMWM primer is applied; PPC goes down at least 15 minutes and within 2 hours after priming, mixed in a mobile mixer and screeded with a self-propelled paver. Traffic can usually return after about 4 hours of cure. TxDOT advises masking joints and drains, and avoiding paving over joints and then saw cutting the overlay. It gives a cost of about $10 to $15/sy and an estimated 20-year life, with no hydrodemolition required. (That cost figure is as printed in the TxDOT guide; confirm current unit costs locally.)

Patching: partial-depth, full-depth and the halo effect

Sealers and overlays protect sound concrete; patching replaces concrete that has already failed. Deck spalls, FDOT notes, are a common outcome of cracking, impact or reinforcement corrosion. Delaminations are typically caused by corrosion at the bar level that cracks the concrete along the bar lines parallel to the surface.

Partial depth versus full depth

FDOT gives a clear switching rule: if unsound concrete is removed to the extent that the bottom mat of reinforcement is exposed, stop the partial-depth procedure and switch to full depth. Its delamination repair photographs show removal to the top mat only, then placement of new material. FDOT's overlay section adds that concrete damaged to or beyond the depth of the bottom layer requires full-depth repair, and that partial- and full-depth repairs may be placed at the same time as a concrete overlay.

Removal and preparation

TxDOT's procedure (applicable specifications: Item 429, "Concrete Structure Repair," and the TxDOT Concrete Repair Manual) is: shallow saw cut around the repair; chipping hammers up to 30 lb for deep removal and 15 lb for shallow removal around reinforcement; remove all unsound concrete; abrasive blast the existing reinforcement and the surrounding substrate before placement. It gives 2020 costs of about $80/sf for partial depth and $130/sf for full depth, and says patching "can be a cost-effective method to restore structural integrity and long-term deck performance for the life of the structure if the root cause(s) has been addressed." FDOT's photographs follow the same sequence: removal, finding delamination at the edge of the patch (which means the boundary must move out), cleaning with compressed air, prepared patch areas, placement, vibration and finishing, and wet curing with blankets or burlap.

Sound the edges

Sounding the boundary of each patch before placement is the step most often skipped. A delamination that continues under the saw cut will lift the new patch's edge within a few seasons. TxDOT recommends sounding near the boundaries of previous repairs during assessment for the same reason.

The halo effect

The FHWA Guide warns that when chloride-contaminated concrete is removed and replaced with chloride-free repair material, "if a high concentration of chlorides remains in the area surrounding the replaced concrete, the corrosion potential will lead to rapid corrosion in the area surrounding the repair." The patch itself is fine; the ring of old concrete around it becomes the new anode. That is why the Guide lists deck repair "in conjunction with overlays, CP systems or ECE treatment" rather than patching alone. FDOT's remedy for localized corrosion is to repair with the spall procedure but attach galvanic anodes to the reinforcement before placing the new concrete, tied to the side of the exposed bar as close as practical to the surrounding concrete, with enough room to encapsulate the anode fully.

When patching is no longer the answer

FDOT says that for widespread corrosion damage, greater than 25 percent of the surface area, a partial-depth deck replacement should be considered, because it removes active corrosion and replaces chloride-contaminated concrete; hydrodemolition is very effective for this. TxDOT considers full deck replacement for decks with extensive severe deterioration, "larger than 30% deck areas require repair," when superstructure and substructure ratings are acceptable, with a life-cycle cost analysis comparing deck replacement to total replacement. The two figures come from different agencies and

describe different actions, but both make the same point: beyond roughly a quarter to a third of the area, patch-by-patch work stops being preservation.

Electrochemical options: galvanic anodes and cathodic protection

When chlorides are already at the steel, barriers on top slow the supply but cannot stop corrosion under way. FDOT describes two electrochemical approaches. Galvanic systems use sacrificial anodes that corrode preferentially to the reinforcement. Cathodic protection systems use impressed electrical current through the reinforcement or conductive materials on the deck to break the corrosion process. The FHWA Guide lists CP and electrochemical chloride extraction (ECE) as condition-based deck preservation.

FDOT's Table 7.3 summarizes:

Goal	Method	Expected annual maintenance	When to apply	Expected life
Corrosion prevention	Sacrificial anodes	Minimal	New concrete	10 to 20 years
Corrosion control (after corrosion has initiated)	Sacrificial anodes	Minimal	No corrosion damage in the concrete	10 to 20 years
Corrosion protection	Impressed current	Moderate	Stop ongoing corrosion	Life of deck

FDOT recommends that for widespread steel corrosion, "consideration should be given to adding a cathodic protection system to slow the corrosion of the repaired deck." Impressed current systems need power, monitoring and maintenance; an agency that installs one without a plan to keep it energized has bought an expensive overlay. BR-C02 discusses electrochemical repair further.

Turning treatments into agency rules

The FHWA Guide asks agencies to write rules that say when an action may be appropriate. A cyclical rule is an action and an interval; a condition-based rule is an action triggered by the condition of an element or component. Its Table 5 example of a cyclical rule, for decks with NBI Item 58 of 7 or better, is:

Preservation activity	Interval (years)
Deck sweeping/washing	1 to 2
Crack sealing	3 to 5
Deck sealing	3 to 5
Polymer overlay	8 to 12
Polymer-modified asphalt overlay	12 to 15

Its Table 6 example of a condition-based rule uses a state's top-surface (58a) and bottom-surface (58b) deck ratings and defect areas:

Top surface before	Top defect area	Bottom surface before	Bottom defect area	Repair option	Top surface after	Bottom after	Service life (yr)
≥5	≤5%	>5	≤2%	Epoxy overlay	8, 9	No change	10 to 15
N/A	≤10%	N/A	≤25%	Deck patch	+1	No change	3 to 10

The Guide stresses that satisfying a rule only means "further evaluation is warranted." Rules do not rank bridges or actions against each other under a budget, and owners may weigh net benefit, duration of service life extension, specialty contractor availability, bundling of bridges along a route, and traffic operations. Those rules then feed life cycle planning, which BR-DP01 and BR-M01 discuss.

Notice what the condition-based example implies. The epoxy overlay is only offered while the deck is still fairly sound (top surface 5 or better, at most 5% defect area, bottom nearly clean), and it is expected to raise the top surface rating to 8 or 9. A deck patch has no condition gate on the rating and raises the rating only by one. Waiting longer narrows the menu to the less durable option.

Choosing a treatment: a decision walk-through

Putting the sources together, a defensible deck decision follows roughly this order. The steps are a synthesis of the FHWA, FDOT and TxDOT material above, not a sequence quoted from any one of them.

1. **Establish the condition and its cause.** Ratings and element quantities, delamination survey, half-cell or resistivity where useful, cores for chloride profile and cover. Is cracking from shrinkage, restraint, overload or corrosion?
2. **Locate the chlorides relative to the steel.** Below about half the threshold at bar depth, barriers have real value (TxDOT recommends an overlay when chloride is at least half of threshold). At or above threshold, the barrier must be combined with removal or electrochemical protection.
3. **Size the repair quantity.** A few percent of area is a patching job ahead of a sealer or overlay. Approaching a quarter to a third of the area, look at partial-depth or full deck replacement (FDOT 25%; TxDOT 30%).
4. **Check the structure's tolerance for weight and grade.** Thin polymers add little; concrete and asphalt overlays need a load rating check and may need approach, joint and rail work.
5. **Check traffic constraints.** Polymer and PPC overlays return to traffic in hours; concrete overlays need days of curing.
6. **Decide the inspection consequence.** An asphalt wearing surface hides the deck from visual, impact echo and infrared inspection.
7. **Price the life cycle, not the first cost.** Compare cost per year of service and the condition the bridge will be in at the end.

Worked example (illustrative numbers)

The following bridge and figures are illustrative only, constructed for this course to show the arithmetic; they are not drawn from any agency record. A 40 ft by 200 ft deck (8,000 sf, about 889 sy) has a top surface rating of 6. A sounding survey finds 240 sf of delamination (3% of area). Cores show chloride at bar depth well below threshold but rising. Using the TxDOT figures printed in its guide as rough unit prices:

- Partial-depth patching: 240 sf x $80/sf = about $19,200.
- Option A, silane after patching: 889 sy x about $10/sy = about $8,900, renewed every 5 to 10 years.

- Option B, multi-layer polymer overlay after patching (with repairs at least 7 days earlier): TxDOT gives a 15 to 20 year life; a local unit price would be needed.
- Option C, concrete overlay: 889 sy x $105/sy = about $93,300, plus up to $100/sy for hydrodemolition, with more than 20 years expected but 8 to 10 days of curing and added dead load.

With 3% damage and modest chlorides, Option B or A would usually be the preservation choice, and Option C would be hard to justify unless ride quality or cover is also a problem. If the survey had found 35% delamination, none of these would be preservation; the TxDOT replacement threshold would apply and a life-cycle comparison of deck replacement versus total replacement would follow. All costs here are 2020-era or undated values from the TxDOT guide and must be replaced with current local bid prices in real work.

Quality control and documenting the work

The best-chosen treatment fails if the deck is not prepared. The common failure modes visible in the sources are almost all preparation or timing problems:

- **Sealers on contaminated or unrepaired concrete.** TxDOT's silane preparation is shot or abrasive blasting to remove oils and contaminants, with deck repair at least 7 days before treatment. It also notes that many silane problems "stem from poor application and an inability to properly test for proper application."
- **Overlays on poorly prepared surfaces.** Shot blasting to the specified profile (CSP-5 for TxDOT MLPO) and pull-off testing before PPC are there because bond is what the overlay depends on.
- **Overlays over unrepaired deck.** TxDOT requires repairs at least 7 days before an MLPO. An overlay over active delaminations will debond.
- **Concrete overlays placed on a dry deck.** The SSD requirement exists to stop the substrate from drawing water out of the overlay.
- **Patches with feathered edges and unsound boundaries.** Saw-cut perimeters and sounding the boundary are the controls.
- **Joints and drains blocked by overlay material.** TxDOT recommends masking them for PPC.

Record what was done, where, with which product and on which date. The next inspector needs that to interpret what they see (a new overlay can hide old delaminations), and the asset management system needs it to learn how long treatments actually last. BR-I10 discusses inspection reports and BR-M01 discusses performance measures.

Matching TxDOT specification items to treatments

One practical benefit of the TxDOT guide is that it ties every deck treatment to a specification item, so a preservation recommendation can go straight into a set of plans. The items it names in Chapter 2 are:

Treatment	TxDOT applicable specification	Structural benefit?	Stated life
Penetrating concrete surface treatment (silane)	Item 483, "Penetrating Concrete Surface Treatment"	No	5 to 10 years
Flood coat / gravity-fed sealant (epoxy or methacrylate)	Item 780, "Concrete Crack Repair"	No	About 5 years
Asphalt overlay and seal coat	Item 316, "Seal Coat"	Not stated	10 to 15 years

Multi-layer polymer overlay	Item 439, "Bridge Deck Overlays"	No	15 to 20 years
Partial and full depth deck repair	Item 429, "Concrete Structure Repair"	Restores integrity	Life of structure if root cause addressed

Other states use different item numbers, so treat the table as an example of the habit worth copying: every recommendation in an inspection or preservation report should name the specification it would be built under.

Two details from the TxDOT text matter for scoping. Silane was discontinued on new decks made with high performance concrete, on the assumption that HPC's low permeability makes extra sealing unnecessary. And flood coats are aimed at extensive shallow cracking of about 5 to 10 percent of the deck surface. They are recommended on decks without delamination, or after partial- or full-depth repairs on decks with isolated delamination, with repairs at least 7 days before the sealant. The resin is spread with squeegees and fine sand is broadcast before it cures. A sanded flood coat can also improve skid resistance, though only temporarily.

Self-check scenarios

Work each scenario before reading the suggested answer. The bridges are hypothetical and constructed for practice; the answers apply only the source guidance quoted in this course.

Scenario 1

A five-year-old HPC deck in good condition, with no cracking of note, is on a district list for silane "because every deck gets it."

Suggested answer: TxDOT discontinued silane on new HPC decks on the assumption that their low permeability makes it unnecessary. Washing on a cyclical rule and monitoring would be the more defensible spend unless the agency has local evidence otherwise.

Scenario 2

An older bare deck shows map cracking over roughly 8% of its surface. Sounding finds no delamination.

Suggested answer: This matches TxDOT's flood coat application (extensive shallow cracking of 5 to 10%, no delamination), with about 5 years expected. If the cracking is widespread and longer life or better skid is wanted, an MLPO (15 to 20 years) is the alternative, after shot blasting to CSP-5.

Scenario 3

During a partial-depth patch, the crew chips through to the bottom mat across part of the area.

Suggested answer: FDOT's rule applies: stop the partial-depth procedure and switch to full depth for that area.

Scenario 4

A district proposes a 2-inch asphalt overlay with no membrane on a concrete deck with active corrosion, to fix ride complaints, and records it as preservation.

Suggested answer: FHWA classes an asphalt patch with no membrane on a concrete deck as maintenance without preservation value. FDOT says to include a membrane unless the asphalt is a temporary measure ahead of planned rehabilitation or

replacement. TxDOT warns that asphalt traps chlorides and moisture. Also check the added dead load and how inspection will be done through the asphalt.

Scenario 5

A survey finds delamination and spalls over 32% of a deck whose superstructure and substructure are in fair condition.

Suggested answer: This exceeds TxDOT's 30% threshold for considering deck replacement and FDOT's 25% for considering a partial-depth replacement. TxDOT recommends a life-cycle cost analysis comparing deck replacement with total bridge replacement.

Scenario 6

Patches placed three years ago are sound, but new spalls are forming in a ring just outside each one.

Suggested answer: This is the halo effect FHWA describes. Future patches should include galvanic anodes (FDOT), and the deck may warrant cathodic protection or another electrochemical treatment, combined with an overlay.

Key takeaways

- Deck preservation should start while the deck is in good or fair condition. FHWA's sample condition-based rule offers an epoxy overlay only to a fairly sound deck and a patch to a worse one.
- Assess the deck before choosing a treatment: sounding, cover, half-cell or resistivity, and the chloride profile at bar depth (TxDOT uses about 1.2 to 1.5 lb/cy as a threshold).
- Penetrating sealers suit sound, dry concrete and need periodic renewal. Viscosity determines which crack sealer suits which crack width.
- Overlays add dead load (except very thin polymers), so an engineer should check the effect on live load capacity.
- Put a waterproofing membrane under asphalt on a concrete deck, or treat the asphalt as temporary. An asphalt patch alone is not preservation.
- Patch to sound concrete. Switch to full depth if the bottom mat is exposed, and use galvanic anodes or other measures against the halo effect.
- Beyond about 25 to 30 percent damaged area (FDOT and TxDOT), deck replacement or partial-depth replacement becomes the option to evaluate.
- Most deck treatment failures trace to surface preparation, moisture condition or overlaying unrepaired concrete.

References

1. FHWA, Bridge Preservation Guide: Maintaining a Resilient Infrastructure to Preserve Mobility, FHWA-HIF-18-022, 2018
2. Florida DOT, Bridge Maintenance Course Series Reference Manual, Chapter 7: Maintenance and Preservation Techniques for Bridge Decks and Slabs (read October 2026)
3. Texas Department of Transportation, Bridge Preservation Guide, Bridge Division, March 2024, Chapter 2: Bridge Decks

Study text only; the final quiz is taken online. Verify all references against the edition your agency has adopted.