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Chapter 24 - Bridge Substructure Decision Aid Matrices

24.1 Decision Aid Introduction

This chapter presents decision aid matrices that can be used to quickly look up common defects and the feasible actions available to address the defects. Feasible actions reference previous chapters where detailed discussion or repair procedures can be found. Preventive maintenance activities with recurrence intervals are listed in separate tables for each superstructure material and related superstructure components.

24.2 Reinforced Concrete Substructure Decision Aid Matrix

24.2.1 Common Reinforced Concrete Condition Based Defects and Treatments

Table 24.1 Concrete Substructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Corrosion	<ul style="list-style-type: none"> • Apply corrosion inhibitor to concrete prior to repairing spalls and delamination. (Section 5.2.4) • Application of Impressed Current Cathodic Protection System. (Section 13.1.6) • Installation of Galvanic Anodes. (Section 13.1.6) • Activated arc spray zinc. (Section 13.1.6) • Apply Electrochemical Techniques. (Section 13.1.7)
Cracking: Non-Working Cracks	<ul style="list-style-type: none"> • Inject with epoxy or urethane based product – Drill holes along crack, clean and dry crack, install ports, seal cracks with an epoxy mastic before injecting epoxy. (Sections 5.8.3, 13.4.5) • FRP Wrap for containment. (Section 13.4.10)
Cracking: Working Cracks	<ul style="list-style-type: none"> • Use flexible sealant such as an asphalt crack sealer, rout crack, clean and dry substrate, fill with flexible sealant. (Section 5.8.1)
Concrete Deterioration: Non-Structural Repair	<ul style="list-style-type: none"> • Form and Pour (Recasting) with concrete tied into rebar, patch with cementitious or polymer-based material. (Sections 5.7, 13.4.1) • Consider Shotcrete. (Section 13.4.4)
Concrete Deterioration: Structural Repair	<ul style="list-style-type: none"> • Check with an engineer before removing concrete, structural lift and shore as per approved procedure, provide supplemental support, drill & grout new rebar into sound concrete, repair with material of appropriate compressive strength. (Sections 13.4.2, 13.7)
Delaminations & Spalling	<ul style="list-style-type: none"> • Remove unsound concrete, blast clean substrate and rebar and patch. (Sections 5.6, 5.7) • Galvanic anodes or impressed current cathodic protection can be paired with spall repairs for enhanced protection against corrosion. (Section 13.1.6)
Lack of Rebar Cover	<ul style="list-style-type: none"> • Apply penetrating sealers or coatings. (Sections 13.1.4, 13.1.5) • FRP wrap for containment. (Section 13.4.10)
Lack of Concrete Strength	<ul style="list-style-type: none"> • Shore and support. (Section 13.7) • Apply reinforced concrete jacket tied into existing or FRP. (Section 13.4.3)
Lack of Reinforcing Strength	<ul style="list-style-type: none"> • External strengthening with FRP. (Section 13.4.10) • External reinforcing such as post-tensioning. (Section 13.4.11)
Chloride Contamination	<ul style="list-style-type: none"> • Apply penetrating sealers or coatings. (Sections 13.1.4, 13.1.5) • Install cathodic protection. (Section 13.1.6) <ul style="list-style-type: none"> ▪ Precast elements: apply zinc mesh and jacket with concrete ▪ Cast-in-place: apply titanium mesh and jacket with concrete ▪ Marine: thermal spray zinc or install zinc hydrogel anode • Apply Electrochemical Extraction. (Section 13.1.7)
Impact Damage	<ul style="list-style-type: none"> • Perform concrete repairs. (Section 5.7) • FRP wrap for strength. (Section 13.4.10)
Uniform Settlement (Simple Span Type Structures)	<ul style="list-style-type: none"> • Reset joints and bearings and monitor. (Section 13.4.7)
Differential Settlement	<ul style="list-style-type: none"> • Re-establish sound foundation per approved plan. (Section 13.4.7)
Scour	<ul style="list-style-type: none"> • Apply bank stabilization techniques, riprap, gabions and mattress. (Section 15.3.1) • Tremie Concrete. (Section 15.3.2) • Grout Bags. (Section 15.3.3) • Sheet Piling. (Section 15.3.4) • Articulated Block. (Section 15.3.5) • Biotechnical, not covered in this manual, see HEC-23 Chapter 6
Undermining	<ul style="list-style-type: none"> • Repair using concrete tremies, pumped, bagged or prepacked. (Section 13.4.8)

24.2.2 Common Reinforced Concrete Preventive Maintenance Activities

Table 24.2 Concrete Substructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Sweeping, Cleaning, and Pressure Washing*	0.5 - 2
Applying Penetrating Crack Sealer	8 - 10
Applying Flexible Crack Filler	2 - 4
Debris Removal	As needed
Waterway Control	As needed
Restore Drainage/ Flushing	0.5 - 2
Erosion Control	As needed
Remove Vegetation	0.5 - 2
Replace Riprap	As needed

*Cleaning and debris removal can be performed on a cyclical basis or as needed depending on the source and accumulation frequency. Pressure washing is most beneficial where the members are exposed to saturation from salt contaminated water. Common locations include superstructure areas under joints, areas with bird debris, etc.

24.3 Steel Substructure Decision Aid Matrix

24.3.1 Common Steel Substructure Condition Based Defects and Treatments

Table 24.3 Steel Substructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Steel Corrosion: Coating Issues	<ul style="list-style-type: none"> • Apply Coating. (Section 18.6)
Steel Corrosion: Electrical Issues	<ul style="list-style-type: none"> • Apply cathodic protection – Sacrificial anodes, activated arc spray zinc. (Section 13.1.6)
Steel Corrosion: Section Loss	<ul style="list-style-type: none"> • Repair as needed (welded, bolted plates). (Section 13.5.2) • Replace Element(s). (Sections 11.5.2, 13.5.3)
Fatigue Cracking	<ul style="list-style-type: none"> • Arrest the crack, retrofit or replace section, clean and apply protective coating. (Section 11.5.3)
Bent/Buckled Steel	<ul style="list-style-type: none"> • Heat Straighten if possible. (Section 11.5.4) • Repair (welded, bolted plates) . (Sections 11.5.2, 13.5.3) • Repair area and/provide supplemental support. (Section 13.5.3)
Crevice Corrosion	<ul style="list-style-type: none"> • Clean and recoat. (Sections 13.2.2, 18.6)
Impact Damage	<ul style="list-style-type: none"> • Provide supplemental support if necessary. (Section 13.5.5) • Heat straighten or replace member(s). (Section 11.5.4) • Shoring and Temporary Supports. (Section 13.7) • Fiber Reinforced Polymer Repairs. (Section 13.4.10)

24.3.2 Common Steel Substructure Preventive Maintenance Activities

Table 24.4 Steel Substructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Sweeping, Cleaning, and Pressure Washing*	0.5 - 2
Spot Paint	8 - 10
Cathodic Protection (Sacrificial Anodes)	2 - 4
Metalizing / Overcoating	As needed
Galvanizing	As needed
Debris Removal	0.5 - 2
Waterway Control	As needed
Restore Drainage / Flushing	0.5 - 2
Erosion Control	As needed
Remove Vegetation	0.5 - 2

*Cleaning and debris removal can be performed on a cyclical basis or as needed depending on the source and accumulation frequency. Pressure washing is most beneficial where the members are exposed to saturation from salt contaminated water. Common locations include superstructure areas under joints, areas with bird debris etc.

24.4 Timber Substructure Decision Aid Matrix

24.4.1 Common Timber Defects and Treatments

Timber repairs involve repair of individual timber piles and timber sway bracing. Pile posting, pile restoration and pile shimming all incorporate a new piece of treated timber in the repair. These methods are cost effective, but will be subjected to the same deterioration. Concrete jacketing, pile augmentation and PVC wrapping are methods which leave the existing pile in its deteriorated state, but replace the section loss with concrete and usually provide a watertight seal. These three methods are more expensive, but provide a level of protection against future deterioration.

Table 24.5 Timber Substructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Checks	<ul style="list-style-type: none"> • Apply protective sealant, epoxy injection, preservative, or protective coating. (Section 13.3.3)
Splits	<ul style="list-style-type: none"> • Scab/splice with new treated timbers. (Section 13.6.2) • Epoxy inject the split. (Section 11.3.4) • Provide supplemental support and replace element(s). (Section 13.7) • Apply protective sealants, preservatives or coatings. (Section 13.3.3) • Reinforce with Fiber Reinforced Polymer (FRP) wraps/strips. (Section 13.6.7)
Decay	<ul style="list-style-type: none"> • Provide supplemental support, if necessary. (Section 13.7) • Remove decayed area or use an in-place treatment (diffusible, non-diffusible, or a fumigant). (Section 13.3.3) • Apply protective sealant, preservative, or protective coating. (Section 13.3.3) • Scab/splice with new timbers. (Section 13.6.2) • Replace element(s)
Crushing	<ul style="list-style-type: none"> • Provide supplemental support, if necessary. (Section 13.7) • Replace damaged sections and supplement or replace with new timbers spliced or scabbed onto sound material. (Section 13.6.2) • Apply protective coating or preservative. (Section 13.3.3) • Apply preservative to all cuts and bolt holes. (Section 13.3.3)
Wear/Abrasion	<ul style="list-style-type: none"> • Remove debris • Provide supplemental support and replace worn sections with treated lumber. (Section 13.7) • Scab/splice with new timbers. (Section 13.6.2) • Protect with PVC or fiberglass liner. (Section 13.6.1)
Pest Infestation	<ul style="list-style-type: none"> • Treat with a diffusible or a fumigant if timber is salvageable (Section 13.3.3) or replace timber. • Apply protective coating or preservative. (Section 13.3.3) • Scab/splice with new timbers. (Section 13.6.2)
Loose/Missing Fasteners	<ul style="list-style-type: none"> • Replace missing hardware with metals compatible with preservative • Treat cuts and bolts holes with preservative. (Section 13.3.3)

24.4.2 Common Timber Preventive Maintenance Activities

Table 24.6 Timber Substructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Sweeping, Cleaning, and Pressure Washing*	0.5 - 2
Secure Loose or Replace Missing Fasteners	As needed
Applying Preservatives	3 - 5 for above ground 1 - 3 for timber in ground contact
Treat in-place with either a diffusible, a non-diffusible, or a fumigant	10 - 15
Replace Damaged or Deteriorated Timbers	As needed
Remove Brush & Vegetation	0.5 - 2
Moisture / Drainage Control	0.5 - 2 See Chapter 13.3.2

*Cleaning and debris removal can be performed on a cyclical basis or as needed depending on the source and accumulation frequency. Pressure washing is most beneficial where the members are exposed to saturation from salt contaminated water. Common locations include superstructure areas under joints, areas with bird debris, etc.

24.5 Chapter 24 Reference List

1. Chapters 5, 7, and 13, this manual.
2. FHWA. *Bridge Inspector's Reference Manual (BIRM)*. Publication No. FHWA NHI 12-049. Washington D.C.: United States Department of Transportation, October 2002, Revised December 2006, Revised February 2012.
3. Illinois Department of Transportation. Bureau of Bridges and Structures Division of Highways. *Bridge Element Inspection Manual*, February 2014.
4. Wan, Baolin and Travis McDaniel. *Repair of Deteriorated Bridge Substructures*. Project 0092-11-08, sponsored by the Wisconsin Highway Research Program (WHRP), May 2013, <http://wisdotresearch.wi.gov/wp-content/uploads/WisDOT-WHRP-project-0092-11-08-brief.pdf>