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Chapter 23 - Superstructure Decision Aid Matrices

23.1 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.

23.2 Concrete Superstructure Decision Aid Matrices

23.2.1 Common Concrete Defects and Treatments

Table 23.1 Concrete Superstructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Cracking	• Seal/Repair Crack – Seal hairline superstructure cracks (epoxy, etc.). • Inject – Epoxy Inject larger superstructure cracks (0.025 inch or wider). (Sections 11.1.4, 11.4.3) • Seal Slab Cracks – Seal top surface cracks in slab superstructures. (Section 7.2.2) • Epoxy Inject – Inject soffit cracking in slab superstructures. (Section 11.4.3)
Delaminations	• Patch and Protect – Remove unsound concrete 1 inch beyond reinforcing steel, blast clean reinforcing, install galvanic anodes and patch. (Sections 7.2.4, 11.4.2, 13.1.6)
Spalling	• Patch – Shallow Patching – Remove unsound concrete 1 inch beyond reinforcing steel, blast clean reinforcing and patch. (Section 11.4.2) • Repair – Extensive Spall Repair – Check with an engineer before removing concrete. Remove unsound concrete, blast clean reinforcing, recast concrete or shotcrete. (Sections 11.4.2, 11.4.2) • Repair and Protect – Galvanic anodes or impressed current (active) cathodic protection can be paired with spall repairs for enhanced corrosion protection. (Sections 7.2.4, 13.1.6)
Reinforcing Steel Repair	• Supplement Rebar – Splicing in new rebar due to corrosion or damage. (Section 11.4.6) • Replace Rebar – Replace corroded or damaged rebar using mechanical splices. (Section 11.4.6)
Rebar Corrosion	• Repair – Remove loose concrete, blast clean steel, supplement steel as needed, patch and seal. (Sections 11.4.2, 11.4.6) • Protect – Install Galvanic Anode Corrosion Protection. (Sections 7.2.4, 13.1.6) • Protect – Install impressed current Cathodic Protection System. (Section 13.1.6)
Prestressing Steel Repair	• Splice Prestressed Strands – Consult an engineer. Remove concrete away from the damaged strand, cut existing strand, install and torque coupler, recast concrete. (Section 11.4.6)
Beam End Damage	• Beam End Repair – Consult an engineer. Jack up girder, remove unsound concrete, blast clean reinforcing, supplement steel as needed and patch. (Section 11.4.4)
Strengthening with FRP	• Strengthen – Apply fiber reinforced polymer strips, sheets or wraps. (Section 11.4.5)
Impact Damage	• Inject Concrete Cracks. (Section 11.4.3) • Repair Reinforcing. (Section 11.4.6) • Repair Damaged Concrete. (Section 11.4.2) • Strengthen Damaged Area – Apply Fiber Reinforced Polymer Strips or Sheets. (Section 11.4.5)

23.2.2 Common Concrete Preventive Maintenance Activities

Table 23.2 Concrete Superstructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Cleaning*	0.5 - 1
Debris Removal*	0.5 - 1
Pressure Washing**	1 - 2
Applying Penetrating Crack Sealer	5 - 10
Bird Netting / Deterrent	One time / Maintenance as needed
Waterproofing Treatments	10 - 15
Application of Impressed Current Cathodic Protection System	One time / Ongoing Maintenance
Installation of Galvanic Anodes for Corrosion protection	10 - 20

*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, splash or spray zones, and areas with bird debris.

23.3 Steel Superstructure Decision Aid Matrices

23.3.1 Common Steel Superstructure Defects and Treatments

Table 23.3 Steel Superstructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Steel Corrosion	• Repair – Repair steel/connection as needed, blast clean and apply protective coating. (Section 11.5.2) • Replace Steel – Consult Engineer before starting work. Replace corroded section. (Section 11.5.2)
Fatigue Cracking	• Grind – Consult Engineer for primary structural members. Grind out small cracks in welds. (Section 11.5.3) • Arrest fatigue – Consult Engineer for primary structural members. Arrest cracks, retrofit or replace steel, blast clean and apply protective coating. (Section 11.5.3) • Supplement Member – Consult Engineer for primary structural members. Supplement cracked section with doubler plates. (Section 11.5.3)
Bent/Buckled Steel	• Straighten Member – Consult Engineer for primary structural members. (Section 11.5.4) • Install Stiffening Members – Consult Engineer. • Replace Member – Consult Engineer.
Loose, Missing or Broken Fasteners	• Tighten bolts as needed. • Replacing rivets or bolts. (Section 11.5.2)
Gusset Plate Distortion	• Install stiffening angles, consult an engineer. (Section 12.4.3)
Gusset Plate Repair	• Stiffen Gusset Plate, consult an engineer. (Section 12.4.3) • Supplement/Strengthen – Install Reinforcing Plate as needed for section loss or damage, consult an engineer. (Section 12.4.3)
Improper Seismic Restrainer Tension	• Adjust Seismic Cable Restrainer. Consult an engineer for required cable sag/tension requirements. (Section 12.6.3)
Broken Seismic Cable Restrainer	• Replace – Consult an engineer for proper cable replacement specifications.
Impact Damage	• Repair – Straighten damaged member, prepare surface and apply coating. Consult Engineer for primary structural members. (Section 11.5.4) • Replace damaged steel – Consult an Engineer.

Table 23.4 Suspension and Cable Stayed Bridge Decision Aid Matrix

Common Deficiency	**Feasible Treatments** Refer to Section 12.5 for additional information
Coating System / Wrapping Failure	• Caulk cable bands, saddles and other connection points. • Repaint or remove and replace cable wrapping.
Cable Corrosion	• Apply corrosion inhibitor to strands. Consult an engineer before starting work.
Cable Pitting or Section Loss	• Protect/Repair – Main suspension cables and cable stays – Consult an Engineer. • Repair or Replace coating – Suspender cables – Consult an engineer. • Replace suspender cables – Consult an engineer.
Fatigue Cracking	• Repair – Broken Strands in main suspension cables and cable stays – consult an engineer. • Repair – Broken strands in suspender cables – Consult an engineer. • Repair or replace coating – Suspender cables – Consult an engineer.
Loose, Missing or Broken Fasteners	• Secure – Tighten bolts as needed in cable bands and saddles or other inspection safety cables. • Repair – Broken or missing anchors of main cables, cable stays or suspender cables – Consult an engineer.
Secure Suspension Hand Cables	• Tighten fasteners /Adjust tension. • Replace cables with section loss.
Broken Cable Strands	• See “Fatigue Cracking” above.
Tighten Cable Band	• Tighten cable band fasteners – Consult an engineer.
Cable Compaction	• Compact main cable as needed – Consult an engineer.
Excessive Cable Vibrations	• Dampen cable vibrations – Consult an engineer.

23.3.2 Common Steel Superstructure Preventive Maintenance Activities

Table 23.5 Steel Superstructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Cleaning*	0.5 - 1
Debris Removal*	0.5 - 1
Pressure Washing**	1 - 2
Install Bird Netting / Deterrent	One Time/Maintenance as Needed
Painting or Metalizing (environment dependent)***	10 - 30
Corrosion Protection (Galvanic)	10 - 20
Apply Cable Corrosion Inhibitor	Upon Observed Corrosion
Cable Vibration Control/Reduction	Upon Observed Vibration
Cable Band Caulking	2 - 3
Cable Rewrapping	Upon Breakdown/Corrosion of Wrapping
Cable Dehumidification	Maintain Automatic Humidity Controlled Systems
Adjusting Seismic Restrainer Cable Tension	As Needed / Post Event
Replacing Missing/Loose Seismic Restrainer Fasteners	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, splash or spray zones, and areas subject to birds.

***Painting includes spot painting, zone painting, and repainting entire bridge. See Section 18.3.

23.4 Timber Superstructure Decision Aid Matrices

23.4.1 Common Timber Defects and Treatments

Table 23.6 Timber Superstructure Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Checks	• Seal – Apply sealant, preservative or protective coating. (Section 11.3.3) • Seal – Fill checks with epoxy. (Section 11.3.4)
Splits	• Seal – Apply sealant, preservative or protective coating. (Section 11.3.3) • Repair – Treat splits with epoxy. (Section 11.3.4) • Repair by clamping the split section. (Sections 11.3.5, 11.6.1) • Repair by stitching the split section. (Section 11.3.5) • Supplement member – Scab a new member over the split section. (Section 11.6.2)
Decay/Crushing	• Preserve – Apply preservative or protective coating for surface decay if timber is salvageable. (Section 11.3.3) • Preserve – Apply fumigants to treat internal decay and fungi if timber is salvageable. (Section 11.3.3) • Repair – Remove decayed/adjacent wood and fill void with epoxy. (Section 11.3.4) • Supplement – Remove decayed section and supplement or replace with new timbers spliced or scabbed onto sound material. (Section 11.6.2) • Replace – Replace member where required or less costly than preserving, repairing, or supplementing. (Section 11.6.4) • Repair with Epoxy (Section 11.3.4)
Pest Infestation	• Treat with fumigants if timber is salvageable. (Section 11.3.3)
Loose/Missing Fasteners	• Tighten or replace fasteners and apply preservative. Consider bolts with washers when possible in lieu of lag bolts.
Inadequate Strength	• Scab steel plates onto the timber. (Section 11.6.2) • Post tension the timber member. (Section 11.6.3) • Replace – Replace member with least costly alternative. (Section 11.6.4)
New Beam Required	• Replace timber member. (Section 11.6.4)

23.4.2 Common Timber Preventive Maintenance Activities

Table 23.7 Timber Superstructure Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Cleaning and Pressure Washing*	0.5 - 1
Secure Loose or Replace Missing Fasteners	As Needed
Apply Waterproofing Seal	2 - 10
Applying Preservatives	3 - 5
Treat with Fumigants	10

*Cleaning and pressure washing can be performed on a cyclical basis or as needed depending on the source and the debris accumulation frequency. Pressure washing should be performed at pressures low enough to avoid damage to the surface of the wood. If pressure washing damages surface of timber, other methods such as flooding should be considered.

23.5 Bearing Decision Matrices

23.5.1 Common Bearing Defects and Treatments

Table 23.8 Bearing Condition Based Decision Aid Matrix

Common Deficiency	Feasible Treatments
Poor Alignment/ Rotation	• Reset the bearings. (Section 12.3.3) • Install bearing restraints as needed. (Section 12.3.5)
Corrosion/ Section Loss	• Clean and apply protective coating. (Section 12.3.6)
Loose, Broken or Missing Fasteners	• Tighten loose or replace missing fasteners – As needed. • Replace anchor bolts. (Section 12.3.4)
Deteriorated Seat Concrete	• Remove unsound concrete and patch. (Section 13.4.2)
Sheared/Crushed Elastomeric Pads	• Replace bearing pads. (Section 12.3.1)
Deteriorated Condition or Function	• Replace when unable to repair. (Section 12.3.1)

23.5.2 Common Bearing Preventive Maintenance Activities

Table 23.9 Bearing Cyclical Preventive Maintenance Activities

Common Activities	Typical Frequency (Years)
Pressure Washing**	0.5 - 1
Cleaning / Debris Removal	1 - 2
Lubricating Bearing (if needed)	1 - 2
Painting or Metalizing	10 - 20
Anchor Bolt Tightening	As Needed
Securing Fasteners	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. Bearings in benign environments, protected from salt contaminated water or protected from debris accumulation may not warrant pressure washing at the noted frequency.

23.6 Chapter 23 Reference List

1. Chapters 11 and 12, 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. FHWA. *Primer for the Inspection and Strength Evaluation of Suspension Bridge Cables*. Publication No. FHWA-IF-11-045. Washington D.C.: United States Department of Transportation, May 2012, http://www.fhwa.dot.gov/bridge/pubs/if11045.pdf