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# Appendix A: Common Defects

## Section A.1: Material Defects

### A.1.1 Steel Defects

#### A.1.1.1 Corrosion (1000)

Section loss of steel is caused by corrosion heavy or severe enough to physically measure a reduction in member thickness.

The inspector should look for areas of laminate rust on the steel surface or areas of heavy blistering paint (caused by a build-up of rust under the paint surface). Common locations are horizontal surfaces, areas subject to salt spray from roads or areas near water surfaces. The most effective tools used to remove the laminate rust are chipping hammers and paint scrapers. Severe corrosion will usually consist of fairly loose, brown laminate rust, and a hard, tightly adhered black corrosion product on the base metal surface. A chipping hammer is usually required to remove this black corrosion. Safety glasses should always be worn when using a chipping hammer.

Once the corrosion has been removed, the amount of remaining section should be measured and recorded. Methods to measure the remaining section include the use of a caliper, a micrometer or ruler with a straight edge spanning the depression to indicate the original steel surface. The surface area affected by the corrosion should also be measured.

Some corrosion is so severe that holes are created through the steel. This situation should be recorded as “through thickness section loss” rather than “100 percent section loss” since the latter term suggests that the entire member or element has corroded away.

Condition States

**Condition State 1** indicates no corrosion exists or it has been repaired and painted over corrosion that has been painted over will not prevent further corrosion from occurring and should not be considered a Condition State 1. Repairs suggest that the member or element has been retrofitted so that it has its original load-carrying capacity. The repairs may be in the form of bolted splices or welded splices.

**Condition State 2** indicates that corrosion of the steel has initiated or freckled rust is present.

**Condition State 3** indicates that section loss or pack rust exists. If the condition is not repaired/rehabilitated, a structural analysis may be warranted in the near future. The inspector should consider recommending cleaning and painting of the member to help prevent further section loss.

**Condition State 4** indicates that excessive section loss exists, and that structural analysis results indicate member capacity or serviceability is compromised.

### A.1.1.2 Cracking – Steel (1010)

Steel cracking addresses fatigue cracks, regardless if they occur within a fracture critical or non-fracture critical bridge. Cracking in substructure elements will most often occur in steel pier caps or cross girders. Any cracks not previously detected should be evaluated to determine the potential for fracture.

Inspectors should be especially thorough at details which are prone to developing fatigue cracking. Refer to Appendix for a list of fatigue details. Detection of these cracks will most often occur during In-Depth or Fracture Critical Inspections but can still be found during Routine Inspections as well. Any crack defects classified as a Condition State 3 or worse should be immediately reported to the Inspection Program Manager. Serious consideration should be given to closing the bridge until the extent and cause of cracking is determined and appropriate remedial action is taken.

#### Condition States

**Condition State 1** indicates that no cracking exists in the member.

**Condition State 2** indicates that a crack exists, but it has either been arrested by drilling holes at the tips or it has been repaired with bolted splices or welded splices. Shallow or short cracks may also be ground out. Unrepaired, self-arrested, or cracks not arrested with drilled holes may also fall into this Condition State, but they are located in a non-critical or redundant member.

**Condition State 3** indicates that a crack which has not been arrested or repaired exists in a primary load-carrying member, including newly-discovered crack or existing cracks that are still growing between inspection cycles. Cracks of this nature suggest it is fatigue related, stable crack growth.

**Condition State 4** indicates that a very large crack exists in any primary load-carrying member. Newly-discovered cracks are greater than 3 inches in length, or existing cracks have grown more than 6 inches within the last 24 months. Cracks of this nature suggest they developed in an uncontrolled brittle fashion.

### A.1.1.3 Connection (1020)

Connections can be constructed from two or more members or elements that may be bolted, riveted, or welded together. Connection deficiencies include any deterioration or damage of fasteners, such as rivets, bolts, or welds and connection plates (gusset plates). Any suspected loose or deteriorated fasteners should be struck with a hammer to determine soundness. Welded connections should be visually inspected for fatigue cracks developing from weld imperfections or overstress. Connections are also often subjected to distortion due to pack rust (corrosion occurring between two pieces of lapped steel). The amount of separation caused by pack rust and any distortion to the steel should be measured and recorded.

#### Condition States

**Condition State 1** indicates that the connection is in place and is functioning as intended.

**Condition State 2** indicates that there are loose fasteners and/or pack rust without distortion. The connection is in place and functioning as intended despite these defects.

**Condition State 3** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. Although these defects are present, the structural capacity of the structure is not reduced.

**Condition State 4** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. These defects reduce the structural capacity of the member assembly.

### A.1.1.4 Distortion (1900)

This defect is used to report distortion from the original line or grade of the element. It is used to capture all distortion regardless of cause.

#### Condition States

**Condition State 1** indicates no distortion.

**Condition State 2** indicates there is distortion that does not require mitigation or previously reported distortion which has been mitigated.

**Condition State 3** indicates there is distortion present which requires mitigation but does not warrant a structural review.

**Condition State 4** indicates there is distortion present which requires mitigation and warrants a structural review to determine the strength or serviceability of the element or a structural review has been completed and the distortion impacts the strength or serviceability of the bridge.

## A.1.1.5 Microbial Induced Corrosion (8001) [ADD]

This defect is used to report degradation of steel caused by Microbial Induced Corrosion (MIC). Microbial induced corrosion is corrosion on metallic surfaces due to bacteria or fungi. Pitting is the typical visual evidence that MIC is occurring. However, in most instances, an inspector will not know if the corrosion is microbial induced unless specifically tested for MIC. Tests can be completed in the field to determine if MIC is present. The Microbial Induced Corrosion defect is only to be used on substructure elements and when determined through testing. The testing results shall be uploaded to the bridge inspection report to remain on file.

### Condition States

**Condition State 1** indicates no corrosion exists or it has been repaired or painted over and the water has been tested and no MIC exists.

**Condition State 2** indicates water tested and MIC exists. Orange powder may exist but little or no corrosion exists. The surface under the orange powder may be shiny, indicating that MIC is actively attacking the steel member.

**Condition State 3** indicates significant section loss exists or isolated areas of deep pitting and corrosion. The structural capacity of the member has not been reduced. The inspector should consider recommending cleaning and painting to help prevent further section loss.

**Condition State 4** indicates that excessive section loss exists due to MIC attack and may have removed enough section loss to warrant a structural review. Results indicate member capacity or serviceability is compromised.

## A.1.2 Reinforced Concrete Defects

### A.1.2.1 Delamination/Spalls/Patched Areas (1080)

Delamination is the result of a loss of bond between concrete and rebar due to expanding corrosion product of corroded reinforcement and can often lead to spalling of the concrete. Spalling is a depression in concrete where sections of concrete separate from aggregate or the reinforcement. Spalls result from the separation and removal of a portion of the surface concrete, revealing a fracture roughly parallel to the surface. Inspectors should use sketches showing the location and dimensions of delaminations and spalls. The depth of spalls should also be recorded.

Condition States

**Condition State 1** indicates that there are no apparent delaminations, spalls, or patched areas.

**Condition State 2** indicates that there are delaminated and/or spalled areas that are less than 1” deep or less than 6” in diameter or in either the length or width dimension. . Any patched areas are sound.

**Condition State 3** indicates that there are spalled areas that are greater than 1” deep or greater than 6” in diameter, or in either the length or width dimension. Patched areas are unsound or showing distress. The delamination, spall, or patched area does not warrant a structural review.

**Condition State 4** indicates that the depths of delaminations, spalls, or patched areas warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.2.2 Exposed Rebar (1090)

Exposed rebar can be the result of spalls, delaminations, or damage. Exposed rebar will be susceptible to accelerated corrosion and deterioration due to its exposure to the environment. Inspectors shall record the area and location of exposed rebar and record any measureable section loss.

Condition States

**Condition State 1** indicates that there is no exposed rebar in the bridge member.

**Condition State 2** indicates that rebar is exposed and surface corrosion may be present but without section loss.

**Condition State 3** indicates that rebar is exposed and surface corrosion is present with measurable section loss but does not warrant a structural review. Caliper/thickness gauge measurements should be used to determine the amount of section loss.

**Condition State 4** indicates that rebar is exposed and surface corrosion is present with measurable section loss and warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge. Caliper/thickness gauge measurements should be used to determine the amount of section loss

### A.1.2.3 Cracking – Reinforced Concrete (1130)

Cracking is common in reinforced concrete due to concrete's lack of strength in tension. Cracking can be a result of structural forces, temperature, or other forces. Common locations for structural cracking include negative moments over a support, near supports from shear stress, and the bottom of elements near mid-span from positive moments. Temperature cracking is caused by thermal expansion and contraction. Shrinkage cracks are due to the shrinkage of concrete caused by the curing process. It can cause either pattern (map) cracking or random cracks. Mass concrete cracks occur due to thermal gradients, the differences between interior and exterior temperatures, in massive sections immediately after the placement and for a period of time afterwards. While all cracking allows moisture and chemicals to infiltrate the concrete, structural cracking is considered more critical as it could be a result of a larger issue. Inspectors should note all visible cracks, recording their type, width, length, and location.

#### Condition States

**Condition State 1** indicates that there is cracking present less than 0.012" wide or any cracks larger are sealed.

**Condition State 2** indicates that there is cracking present between 0.012" and 0.05" wide. Where efflorescence is present, it's minor and there is no evidence of rust staining.

**Condition State 3** indicates that there is cracking greater than 0.05" wide. Where efflorescence is present there is heavy build-up and/or rust staining.

**Condition State 4** indicates the cracking warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.2.4 Abrasion/Wear (1190) (PSC/RC)

Vehicular traffic is a source of abrasion and wear on concrete decks. Abrasion occurs on concrete piles that are subjected to flowing water or tidal flows. Mechanical wear of concrete members sometimes occurs due to movement of the fasteners against their holes when connections become loose.

#### Condition States

**Condition State 1** indicates no abrasion.

**Condition State 2** indicates abrasion has exposed coarse aggregate but the aggregate remains secure in the concrete.

**Condition State 3** indicates coarse aggregate is loose or has popped out of the concrete matrix due to abrasion.

**Condition State 4** indicates the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.2.5 Chloride Concentration (8905) [ADD]

Chloride contamination is caused primarily by deicing agents. Chloride ions infiltrate concrete through surface cracks. Chloride ions break down the passivation layer around bare reinforcing steel allowing for corrosion to occur. Testing for chlorides involves drilling out samples and testing the content at certain depths. Once the chloride content reaches a certain limit at the reinforcing depth, bare steel reinforcing is at risk. This defect is used to capture defects in concrete that have chlorides in excessive amounts.

The Chloride Concentration defect is only to be used on deck and slab elements and when properly tested. Test results shall be uploaded to HSI with the bridge inspection report.

#### Condition States

**Condition State 1** indicates chloride concentration at level of rebar tested below the threshold for potential active corrosion.

**Condition State 2** indicates chloride concentration at level of rebar tested equal to or greater than the threshold for potential active steel corrosion. No visual signs of active corrosion exist.

**Condition State 3** indicates chloride concentration at level of rebar tested greater than the threshold for potential active steel corrosion. Testing methods (such as half-cell potential) have been used and have verified active steel corrosion.

**Condition State 4** is not used for this defect. Other reinforced or prestressed concrete defects control the Condition State over chloride concentrations (elevated levels of chloride concentrations may be cause of controlling defects).

Chloride concentration thresholds at the level of top mat reinforcing are as follows:

- **2.0 lbs/CY:** High probability of active corrosion. Recommend utilizing Half-Cell testing method to survey deck for active regions of corrosion.

### A.1.2.6 Precast Concrete Connections (8906) [ADD]

This defect is used to quantify the condition of the connections used between two precast bridge members joined together, such as shear keys or fasteners used in accelerated bridge construction projects.

Condition States

**Condition State 1** indicates no deficiencies are noted.

**Condition State 2** indicates that minor cracking at the joints may be present. The connection is still functioning as intended.

**Condition State 3** indicates cracking, spalling, and/or other deficiencies indicating that the members are acting independently. No displacement of members is evident.

**Condition State 4** indicates the connection is failing or has failed. The structural capacity has been affected. Exterior members may be separating from the adjacent members. Members may be acting individually under traffic loads. The condition warrants a structural analysis to determine the effect on strength or serviceability of the bridge; or a structural review has been completed and the defect impacts the strength and/or serviceability of the bridge.

## A.1.3 Prestressed Concrete Defects

### A.1.3.1 Delamination/Spalls/Patched Areas (1080)

Delamination is the result of a loss of bond between concrete and rebar due to expanding corrosion product of corroded reinforcement and can often lead to spalling of the concrete. Spalling is a depression in concrete where sections of concrete separate from aggregate or the reinforcement. Spalls result from the separation and removal of a portion of the surface concrete, revealing a fracture roughly parallel to the surface. Inspectors should use sketches showing the location and dimensions of delaminations and spalls. The depth of spalls should also be recorded.

Condition States

**Condition State 1** indicates that there are no apparent delaminations, spalls, or patched areas.

**Condition State 2** indicates that there are delaminated and/or spalled areas that are less than 1” deep or less than 6” in diameter or in either the length or width dimension. . Any patched areas are sound.

**Condition State 3** indicates that there are spalled areas that are greater than 1” deep or greater than 6” in diameter, or in either the length or width dimension. Patched areas are unsound or showing distress. The delamination, spall, or patched area does not warrant a structural review.

**Condition State 4** indicates that the depths of delaminations, spalls, or patched areas warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.3.2 Exposed Prestressing (1100)

Exposed prestressing is often the result of impact damage from traffic. Exposed strands will be susceptible to accelerated corrosion and deterioration due to its exposure to the environment. Inspectors should record the area and location of the exposed prestressing and pay special attention to any partially, fully severed or damaged strands. Loss of prestress due to failure of prestressing steel may result in a serious defect manifested in loss of camber, beam sag, and/or wide structural cracks.

#### Condition States

**Condition State 1** indicates that there are no exposed or signs of exposed prestressing strands in the bridge member.

**Condition State 2** indicates that there is exposed prestressing with no section loss.

**Condition State 3** indicates that there is exposed prestressing with section loss. The amount of deterioration does not warrant structural review.

**Condition State 4** indicates that there is exposed prestressing and it warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.3.3 Cracking – Prestressed Concrete (1110)

Concrete cracks might indicate a significant loss in strength in prestressed concrete members. Loss of prestress due to failure of prestressing steel may result in a serious defects manifested in loss of camber, beam sag, and/or wide structural cracks. Inspectors should note all visible cracks, recording their type, width, length, and location.

#### Condition States

**Condition State 1** indicates that there is cracking present less than 0.004” wide or any wider cracks are sealed.

**Condition State 2** indicates that there is cracking present between 0.004” and 0.009” wide. Where efflorescence is present, it’s minor and there is no evidence of rust staining.

**Condition State 3** indicates that there is cracking present greater than 0.009”. Where efflorescence is present, there is heavy build up or rust staining.

**Condition State 4** indicates that there is cracking which warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.3.4 Abrasion/Wear (1190) (PSC/RC)

Vehicular traffic is a source of abrasion and wear on concrete decks. Abrasion occurs on concrete piles that are subjected to tidal flows. Mechanical wear of concrete members sometimes occurs due to movement of the fasteners against their holes when connections become loose.

#### Condition States

**Condition State 1** indicates no abrasion.

**Condition State 2** indicates abrasion has exposed coarse aggregate but the aggregate remains secure in the concrete.

**Condition State 3** indicates coarse aggregate is loose or has popped out of the concrete matrix due to abrasion.

**Condition State 4** indicates the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.3.5 Chloride Concentration (8905) [ADD]

Chloride contamination is caused primarily by deicing agents. Chloride ions infiltrate concrete through surface cracks. Chloride ions break down the passivation layer around bare reinforcing steel allowing for corrosion to occur. Testing for chlorides involves drilling out samples and testing the content at certain depths. Once the chloride content reaches a certain limit at the reinforcing depth, bare steel reinforcing is at risk. This defect is used to capture defects in concrete that have chlorides in excessive amounts.

The Chloride Concentration defect is only to be used on deck and slab elements. Test results shall be uploaded to HSI with the bridge inspection report.

#### Condition States

**Condition State 1** indicates chloride concentration at level of rebar tested below the threshold for potential active corrosion.

**Condition State 2** indicates chloride concentration at level of rebar tested equal to or greater than the threshold for potential active steel corrosion. No visual signs of active corrosion exist.

**Condition State 3** indicates chloride concentration at level of rebar tested greater than the threshold for potential active steel corrosion. Testing methods (such as half-cell potential) have been used and have verified active steel corrosion.

**Condition State 4** is not used for this defect. Other reinforced or prestressed concrete defects control the Condition State over chloride concentrations (elevated levels of chloride concentrations may be cause of controlling defects).

Chloride concentration thresholds at the level of top mat reinforcing are as follows:

- **2.0 lbs/CY:** High probability of active corrosion. Recommend utilizing Half-Cell testing method to survey deck for active regions of corrosion.

### A.1.3.6 Precast Concrete Connections (8906) [ADD]

This defect is used to quantify the condition of the connections used between two precast substructure members joined together, such as shear keys or fasteners used in accelerated bridge construction projects.

Condition States

**Condition State 1** indicates no deficiencies are noted.

**Condition State 2** indicates that minor cracking at the joints may be present. The connection is still functioning as intended.

**Condition State 3** indicates cracking, spalling, and/or other deficiencies indicating that the members are acting independently. No displacement of members is evident.

**Condition State 4** indicates the connection is failing or has failed. The structural capacity has been affected. Exterior members may be separating from the adjacent members. Members may be acting individually under traffic loads. The condition warrants a structural analysis to determine the effect on strength or serviceability of the bridge; or a structural review has been completed and the defect impacts the strength and/or serviceability of the bridge.

## A.1.4 Timber Defects

### A.1.4.1 Connection (1020)

Timber members are often connected with steel fasteners including nails, screws, bolts, and tension rods and are thus subject to the same deficiencies as steel members. Loose or failed connections can be due to pull out or pull through of fasteners, shrinkage of the wood, crushing of the wood around the fastener, or from repetitive impact loading (working) of the connection. Loose or failed connections can reduce the bridge's load-carrying capacity.

Condition States

**Condition State 1** indicates that the connection is in place and is functioning as intended

**Condition State 2** indicates that there are loose fasteners and/or pack rust without distortion of the hardware but no loss of section. The connection is in place and functioning as intended despite these defects.

**Condition State 3** indicates that there are missing bolts, nails, screws, or other fasteners, and/or pack rust with distortion of the fasteners. Although these defects are present, a structural review is not warranted.

**Condition State 4** indicates that there are missing bolts, rivets, nails, broken welds, screws, or other fasteners, and/or pack rust with distortion warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.4.2 Decay /Section Loss (1140)

Natural decay of timber can occur when there are favorable combinations of oxygen, temperature, food, and moisture. This occurs at locations such as connections, ground lines, and splash zones. Either of these defects can result in section loss of the member. Inspectors should use hammer sounding and picks/awls to determine the extent of decay and inspect damage.

Condition States

**Condition State 1** indicates that no decay or section loss is present in the bridge member.

**Condition State 2** indicates that decay or section loss affects less than 10% of the member section

**Condition State 3** indicates that decay or section loss affects greater than 10% of the member section but does not warrant structural review.

**Condition State 4** indicates that amount of decay or section loss warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a

structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.4.3 Checks/Shakes/Cracks/ Splits/ Delamination (1150)

Natural defects are those inherent in the material and are a result of the natural behavior of timber. Checks are the separation of fibers occurring perpendicular to growth rings and parallel to the grain. Shakes are the separation of fibers parallel to the grain between growth rings. Splits are checks which extend completely through the member. Delaminations occur in glued-laminated members when the layers separate due to failure within the adhesive, or the bond between the adhesive and the laminate. They provide openings for decay to begin and may cause a reduction in strength. Each timber member has a certain ultimate load capacity. If this load capacity is exceeded, the member will fail, typically through cracking. Cracking occurs against the grain and should not be confused with natural occurring defects. Failure modes include horizontal shear failure, bending or flexural failure, and crushing.

Condition States

**Condition State 1** indicates that there are no checks, shakes, cracks, splits or delmainations.

**Condition State 2** indicates that checks or cracks have surface penetration less than 5% of the member thickness. There are no splits, shakes or delaminations. .

**Condition State 3** indicates that checks or cracks have surface between 5% and 50% of the member thickness and not in a tension zone. Member has splits and/or shakes with length less than member depth. Larger cracks, splits or shakes have been arrested with effective repair.

**Condition State 4** indicates that checks or cracks penetrate greater than 50% of member thickness or greater than 5% in the tension zone. The member has splits or shakes with a length greater than the member depth and have not been arrested and warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.4.4 Abrasion/Wear - Timber (1180)

Vehicular traffic is the main source of abrasion on timber decks. Abrasion occurs on timber piles that are subjected to flowing water or tidal flows. Mechanical wear of timber members sometimes occurs due to movement of the fasteners against their holes when connections become loose.

Condition States

**Condition State 1** indicates that no wear or abrasion is present.

**Condition State 2** indicates that wear and abrasion has caused section loss less than 10% of the member thickness.

**Condition State 3** indicates that wear and abrasion has caused section loss greater than 10% of the member thickness but strength or serviceability of the bridge is not affected and does not require a structural review.

**Condition State 4** indicates that damage is greater than 10% of the member thickness and the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.4.5 Distortion (1900)

This defect is used to report distortion from the original line or grade of the element. It is used to capture all distortion regardless of cause. Glulam and other built up timber members are connected with glue and are subject to failure by improper application, which can lead to distortion of the timber member.

Condition States

**Condition State 1** indicates no distortion.

**Condition State 2** indicates there is distortion that does not require mitigation or previously reported distortion which has been mitigated.

**Condition State 3** indicates there is distortion present which requires mitigation but does not warrant a structural review.

**Condition State 4** indicates there is distortion present which requires mitigation and warrant a structural review to determine the strength or serviceability of the element or a structural review has been completed and the distortion impacts the strength or serviceability of the bridge.

## A.1.5 Masonry Defects

### A.1.5.1 Mortar Breakdown (1610)

Inspection of mortar is similar to that of concrete. Inspectors should carefully inspect the joints for cracks, vegetation, water seepage, weathering, spalls and split blocks. Cracks or openings allow water, debris, and chemicals into the mortar which will accelerate the deterioration of the mortar and stones. Inspectors should detail the linear length of mortar deterioration and uses sketches where applicable.

Condition States

**Condition State 1** indicates that there is no mortar breakdown on the bridge element.

**Condition State 2** indicates that cracking or voids in the mortar cover less than 10% of the joints.

**Condition State 3** indicates that cracking or voids in the mortar cover more than 10% of the joints but does not warrant a structural review.

**Condition State 4** indicates that cracking or voids in the mortar cover more than 10% and warrants a structural review to determine the effect on strength or serviceability of the bridge element, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge

### A.1.5.2 Spall/Split/Patched Area (1620)

Cracking of masonry stones occurs when part of the internal structure of the stone is fractured, allowing water/chemicals to seep into the stone interior. Splitting of masonry stones occurs when seams or cracks open up in stones, breaking them into smaller pieces. Patched areas are locations with previous defects that have been repaired. Inspectors should determine if the patch is functioning properly and sound, if the patch is showing any signs of distress, or if the serviceability of the bridge is affected and if another repair method needs to be implemented.

Condition States

**Condition State 1** indicates that there are no splits or spalls on the bridge member.

**Condition State 2** indicates that the block or stone has split or spalled with no shifting. Any patched areas are sound.

**Condition State 3** indicates that the block or stone has split or spalled with shifting but does not warrant a structural review. Patched areas are not sound.

**Condition State 4** indicates that the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.5.3 Masonry or Panel Displacement (1640)

Displacement is a form of localized settlement or misalignment. This defect, which typically affects masonry structures due to the weight of the material, can result in differential settlement. Superstructure and substructure units should be checked for any new or unusual cracking. General alignment of stones along the element should remain constant. Missing stones allow moisture and vegetation to enter masonry units and develop or accelerate other forms of deterioration.

#### Condition States

**Condition State 1** indicates that no masonry or panel displacement exists in the bridge member.

**Condition State 2** indicates that blocks, panels or stones have shifted slightly out of alignment.

**Condition State 3** indicates that blocks, panels or stones have shifted significantly out of alignment and/or blocks or stones are missing but does not warrant a structural review.

**Condition State 4** indicates that masonry displacement warrants a structural review to determine the effect on strength or serviceability of the bridge element or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

## A.1.6 Other Materials Defects

### A.1.6.1 Corrosion (1000)

Section loss of a material is caused by corrosion heavy or severe enough to physically measure a reduction in member thickness.

The inspector should look for areas of laminate rust on the material surface or areas of heavy blistering paint (caused by a build-up of rust under the paint surface). Common locations are horizontal surfaces, areas subject to salt spray from roads or areas near water surfaces. The most effective tools used to remove the laminate rust are chipping hammers and paint scrapers. Severe corrosion will usually consist of fairly loose, brown laminate rust, and a hard, tightly adhered black corrosion product on the base metal surface. A chipping hammer is usually required to remove this corrosion. Safety glasses should always be worn when using a chipping hammer.

Once the corrosion has been removed, the amount of remaining section should be measured and recorded. Methods to measure the remaining section include the use of a caliper, a micrometer or ruler with a straight edge spanning the depression to indicate the original material surface. The surface area affected by the corrosion should also be measured.

Some corrosion is so severe that holes are created through the material. This situation should be recorded as “through thickness section loss” rather than “100 percent section loss” since the latter term suggests that the entire member or element has corroded away.

Condition States

**Condition State 1** indicates no corrosion exists or it has been repaired and painted over corrosion that has been painted over will not prevent further corrosion from occurring and should not be considered a Condition State 1.

**Condition State 2** indicates that corrosion has initiated. Freckled rust may be present.

**Condition State 3** indicates that section loss or pack rust exists but does not warrant a structural review.

**Condition State 4** indicates that excessive section loss exists, and that structural analysis results indicate member capacity or serviceability is compromised.

### A.1.6.2 Cracking (1010)

Cracking addresses fatigue cracks of a material, regardless if they occur within a fracture critical or non-fracture critical bridge. Cracking in substructure elements will most often occur in pier caps or cross girders. Any cracks not previously detected should be evaluated to determine the potential for fracture.

Inspectors should be especially thorough at details which are prone to developing fatigue cracking. Refer to Appendix D for a list of fatigue details. Detection of these cracks will most often occur during In-Depth or Fracture Critical Inspections but can still be found during Routine Inspections as well. Any crack defects classified as a Condition State 3 or worse should be immediately reported to the Inspection Program Manager. Serious consideration should be given to closing the bridge until the extent and cause of cracking is determined and appropriate remedial action is taken.

#### Condition States

**Condition State 1** indicates that no cracking exists in the member.

**Condition State 2** indicates that a crack exists, but it has either been arrested by drilling holes at the tips or it has been repaired with bolted splices or welded splices. Shallow or short cracks may also be ground out. Unrepaired, self-arrested, or cracks not arrested with drilled holes may also fall into this Condition State, but they are located in a non-critical or redundant member.

**Condition State 3** indicates that a crack which has not been arrested or repaired exists in a primary load-carrying member, including newly-discovered crack or existing cracks that are still growing between inspection cycles. Cracks of this nature suggest it is fatigue related, stable crack growth.

**Condition State 4** indicates that a very large crack exists in any primary load-carrying member. Newly-discovered cracks are greater than 3 inches in length, or existing cracks have grown more than 6 inches within the last 24 months. Cracks of this nature suggest they developed in an uncontrolled brittle fashion.

### A.1.6.3 Connection (1020)

Connections can be constructed from two or more members or elements that may be bolted, riveted, or welded together. Connection deficiencies include any deterioration or damage of fasteners, such as rivets, bolts, or welds and connection plates (gusset plates). Any suspected loose or deteriorated fasteners should be struck with a hammer to determine soundness. Welded connections should be visually inspected for fatigue cracks developing from weld imperfections or overstress. Connections are also often subjected to distortion due to pack rust (corrosion occurring between two pieces of lapped steel). The amount of separation caused by pack rust and any distortion to the steel should be measured and recorded.

Condition States

**Condition State 1** indicates that the connection is in place and is functioning as intended.

**Condition State 2** indicates that there are loose fasteners and/or pack rust without distortion. The connection is in place and functioning as intended despite these defects.

**Condition State 3** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. Although these defects are present, the structural capacity of the structure is not reduced.

**Condition State 4** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. These defects reduce the structural capacity of the member assembly.

### A.1.6.4 Delamination/Spalls/Patched Areas (1080)

Delamination is the result of a loss of bond between concrete and rebar due to expanding corrosion product of corroded reinforcement and can often lead to spalling of the concrete. Spalling is a depression in concrete where sections of concrete separate from aggregate or the reinforcement. Spalls result from the separation and removal of a portion of the surface concrete, revealing a fracture roughly parallel to the surface. Inspectors should use sketches showing the location and dimensions of delaminations and spalls. The depth of spalls should also be recorded. This defect is used only for jacketing and external post tensioning only.

Condition States

**Condition State 1** indicates that there are no apparent delaminations, spalls, or patched areas.

**Condition State 2** indicates that there are delaminated and/or spalled areas that are less than 1” deep or less than 6” in diameter or in either the length or width dimension. . Any patched areas are sound.

**Condition State 3** indicates that there are spalled areas that are greater than 1” deep or greater than 6” in diameter, or in either the length or width dimension. Patched areas are unsound or showing distress. The delamination, spall, or patched area does not warrant a structural review.

**Condition State 4** indicates that the depths of delaminations, spalls, or patched areas warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.1.6.5 Deterioration (1220)

Deterioration can be considered the material breakdown of the element. This may include debonding, fraying or discoloration in FRP or similar materials.

Condition States

**Condition State 1** indicates that there is no deterioration occurring.

**Condition State 2** indicates that the material has initiated breakdown or deterioration.

**Condition State 3** indicates that there is significant deterioration or breakdown, but it does not warrant a structural review.

**Condition State 4** indicates that the deterioration or breakdown has become severe enough to warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the deterioration or breakdown impact strength or serviceability of the element or bridge.

### A.1.6.6 Distortion (1900)

This defect is used to report distortion from the original line or grade of the element. It is used to capture all distortion regardless of cause.

Condition States

**Condition State 1** indicates no distortion.

**Condition State 2** indicates there is distortion that does not require mitigation or previously reported distortion which has been mitigated.

**Condition State 3** indicates there is distortion present which requires mitigation but does not warrant a structural review.

**Condition State 4** indicates there is distortion present which requires mitigation and warrants a structural review to determine the strength or serviceability of the element or a structural review has been completed and the distortion impacts the strength or serviceability of the bridge.

## Section A.2: Structural Defects

### A.2.1 Substructure Defects

#### A.2.1.1 Settlement (4000)

Settlement refers to the vertical, rotational, and lateral movement of substructure elements caused by scour, soil failures or foundation failures. Any particular element may experience a combination of these movements as well.

Inspection

Settlement inspection for substructures should include the following items:

- Looking for expansion joints which have opened up excessively at abutments and have either closed completely or opened up above the piers. A closed expansion joint above a pier suggests that the pier has settled. These are all signs of differential pier settlement.
- Checking/measuring the clearance between girder ends and abutment backwall.
- Checking/measuring the clearance between the girder ends on bridges with multiple simple spans.
- Checking/measuring the alignment of expansion bearings relative to the masonry plate and backwall. Excessive superstructure expansion in hot weather or contraction in cold weather may actually be a sign of substructure rotation or sliding.
- Looking for transverse cracks in columns or shafts.
- Sighting down the superstructure parapet to look for unusual dips or sweeps.
- Checking for tipping/rotation by using a plumb bob and laterally sighting the element from a distance.
- Looking for bridge elements that do not line up with one another, such as wingwalls that have shifted laterally relative to the abutment at an expansion joint.
- Investigating existing cracks for continued widening since previous inspections. Measurements and dates taken should be taken and recorded, and written with keel directly on the element.
- Looking for heaving in front of abutments or wingwalls and settlement of approaches.
- Looking for embankment erosion in front of abutments and wingwalls.

Condition States

**Condition State 1** indicates that no settlement has occurred.

**Condition State 2** indicates that settlement has occurred and has been arrested with effective countermeasures.

**Condition State 3** indicates that minor settlement has occurred. Countermeasures have been taken but movement is still evident. Currently, the settlement does not warrant a structural review.

**Condition State 4** indicates that the settlement warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.2.1.2 Scour (6000)

Scour of a streambed is caused by the erosive effects of water flow. High floodwater velocities can lift soil and rock particles from the streambed and transport them downstream. The effect is even greater when obstructions within the stream flow, such as a bridge pier, abutment or wingwall, create localized turbulence (usually on the upstream face). Turbulent waters often scour deep holes adjacent to a bridge pier, possibly undermining the footing. Streambed voids created during high flow are often filled back in with upstream sediment after high flows; masking the fact that scour took place.

Many bridge failures have been caused solely by scour. Under extreme circumstances, scour can cause foundation undermining (soil erosion on the underside of a footing) and tipping of a substructure unit. Scouring underneath of a spread footing is also dangerous because it removes soil from underneath the footing's toe, the area of soil most highly stressed due to lateral loads. The existence of scour does not necessarily mean settlement or tipping of the substructure has occurred.

#### Inspection

Inspection for scour is one of the most important bridge inspection tasks since scour can fail an otherwise sound structure. Unfortunately, scour inspection can also be one of the most difficult tasks to perform. For purposes of this section, it is assumed that probing with a rod (usually a surveyor's range pole) can be performed from a boat or by wading. When this is not feasible, underwater inspection by divers or remote sensing using ground-probing radar is required.

Scour inspection using probing should include the following items:

- Using a probing rod around the substructure to check for scour. Signs of scour include an exposed top or side of the footing. It is rare that the original design called for the footing to be exposed. Also, excessively loose or unconsolidated sediment in the streambed (as compared to the sediment away from the substructure) suggests an area of scour during peak flows.

- Sounding with a weighted line around the substructure to check for scour. This will normally be done from a boat when water depth is too great for wading. This method will not easily detect undermining of the footing.

- Recording the length and depth of scour holes. Depth from the bottom of the hole to the water surface should be recorded. Tying the current water elevation to the bridge elevation will require a second measurement from the water surface to some fixed point on the bridge.

- Using a probing rod around the substructure to check for undermining. The bottom of a footing can be found by scraping the rod tip along the footing side until the bottom corner is found. The length and depth of the scour hole should be recorded.

- Careful probing around substructures with debris accumulation, as debris can increase water flow velocity and the potential for scour. Remove this debris during the inspection if possible. Debris accumulation can also be a safety hazard for the inspectors so care must be taken when working in these situations.

Condition States

**Condition State 1** indicates no scour has occurred.

**Condition State 2** indicates that scour has exposed the top of the footing. No undermining is evident. Counter measures are in place and functioning properly. Minor scour may be present around pile bents. No significant loss of channel material has occurred when compared to previous measurements.

**Condition State 3** indicates that scour has exposed vertical face(s) of the footing. No undermining of spread footing or minor undermining of pile supported footing. There is moderate scour around pile bents. Measurements indicate active channel movement. The scour currently does not warrant a structural review.

**Condition State 4** indicates that the condition of the scour condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

## Section A.3: Element Specific Defects

### A.3.1 Wingwall Defects

#### A.3.1.1 Wall Movement (8902) [ADD]

This defect is for wall and integral wingwall elements and is used to quantify the extent and severity of wall or wingwall movement. Wall or Wingwall movement can be induced through settlement of the wall or wingwall foundation, excessive stress from the soil back-fill, or improper construction of the wall or wingwall. The inspector should note the angle that the wall or wingwall is tipped to see if the tipping is advancing.

Condition States

**Condition State 1** indicates that the wall or wingwall has not moved from its original position.

**Condition State 2** indicates that the wall or wingwall has had some differential movement occur. Wall may be strapped to prevent further movement.

**Condition State 3** indicates that the wall or wingwall rotation, sliding, or settlement is occurring. Sloughing of the retained material behind the wall is evident.

**Condition State 4** indicates that the wall or wingwall has failed and no longer retains the material behind the wall.

#### A.3.1.2 Wall Deterioration (8903) [ADD]

This defect is for wall and integral wingwalls and is used to quantify the extent and severity of wall or wingwall material deterioration. Since wingwalls can be made of various materials, the inspector will refer to the specific material defects associated with the wingwall material.

Condition States

**Condition State 1** indicates that the wall or wingwall has no deterioration.

**Condition State 2** indicates that the wall or wingwall material has deterioration described in the applicable CS 2 material defects for section loss and wall integrity.

**Condition State 3** indicates that the wall or wingwall material has deterioration described in the applicable CS 3 material defects for section loss and wall integrity.

**Condition State 4** indicates that the wall or wingwall material has deterioration or section loss that has caused the wing to fail and no longer retain fill material.

## A.3.2 Bearing Defects

### A.3.2.1 Corrosion (1000)

Any bearing which is made from or has steel or other metal parts is susceptible to corrosion. Bearings are typically located near bridge joints, which increase their exposure to water, debris, and other roadway chemicals, which can accelerate the process of corrosion. Excessive corrosion can cause bearings to bind up or freeze. Inspectors should check all bearing elements for any pitting, section loss, or deterioration.

Condition States

**Condition State 1** indicates no corrosion.

**Condition State 2** indicates that corrosion of the steel has initiated and/or freckle rust is present.

**Condition State 3** indicates that section loss is evident or pack rust is present but it does not warrant a structural review.

**Condition State 4** indicates that the section loss and/or pack rust warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.3.2.2 Connection (1020)

Bearing connections to other bridge elements can be bolted, riveted, or welded together. Connection deficiencies include any deterioration or damage of fasteners, such as rivets, bolts, or welds. Any suspected loose or deteriorated fasteners should be struck with a hammer to determine soundness. Welded connections should be visually inspected for cracks developing from weld imperfections or overstress. Connections are also often subject to deterioration from pack rust (corrosion occurring between two pieces of lapped steel). The amount of separation caused by pack rust should be measured and recorded.

Condition States

**Condition State 1** indicates that the connection is in place and is functioning as intended.

**Condition State 2** indicates that there are loose fasteners and/or pack rust without distortion present. The connection is in place and functioning as intended despite these defects.

**Condition State 3** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. Although these defects are present, a structural review is not warranted.

**Condition State 4** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. These defects warrant a structural review to determine

the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.3.2.3 Movement (2210)

This defect is used to report the movement of bridge bearing elements. The ability of free movement is essential for allowing bridge bearings to function correctly. Inspectors should look for frozen bearings and any potential debris or defect that would prevent a bearing from using the full area of movement for which it was designed.

#### Condition States

**Condition State 1** indicates the bearing is free to move.

**Condition State 2** indicates there is minor restriction to the bearings movement.

**Condition State 3** indicates the bearing is restricted from movement but the situation does not warrant a structural review.

**Condition State 4** indicates the bearing is restricted from movement and the situation warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.3.2.4 Alignment (2220)

This defect is used to report the alignment of bridge bearing elements. Inspectors should compare bearing alignment to other bearings at the same location and other locations on the bridge. Bearing alignment should match environmental conditions at the time of inspection (i.e. expansion when hot, contraction when cold). Bearing assemblies must also be checked to ensure they are aligned in the direction of intended movement, that is they are not skewed to the direction of a girder.

#### Condition States

**Condition State 1** indicates the lateral and vertical alignment is as expected for the temperature conditions.

**Condition State 2** indicates the lateral or vertical alignment is inconsistent with the temperature conditions but the alignment is tolerable.

**Condition State 3** indicates the lateral or vertical alignment is approaching the limits of bearings ability to function but does not warrant a structural review.

**Condition State 4** indicates the bearings alignment warrants a structural review or that a structural review has been completed and the alignment impacts the strength or serviceability of the bridge.

### A.3.2.5 Bulging, Splitting, or Tearing (2230)

This defect is used to report bulging, splitting, or tearing of elastomeric bearing elements. This defect is also applicable to the disk material of disk bearings. Excessive amounts of bulging, wearing, and tearing can dramatically decrease the life of a bearing and accelerate the deterioration caused by other defects.

#### Condition States

**Condition State 1** indicates there is no bulging, splitting, or tearing in the bearing.

**Condition State 2** indicates bulging is less than 15% of the thickness and there is no splitting or tearing.

**Condition State 3** indicates bulging is 15% or more of the thickness or any splitting or tearing. The bearing's surfaces are no longer parallel but does not warrant a structural review.

**Condition State 4** indicates bulging is 15% or more of the thickness or any splitting or tearing and requires a structural review to determine the effect of the defect on the strength or serviceability of the element or bridge or that a structural review has been completed and the bulging, splitting, or tearing impacts the strength or serviceability of the bridge.

### A.3.2.6 Loss of Bearing Area (2240)

This defect is used to report the loss of bearing area for bridge bearing elements. The loss of bearing area can affect the alignment, movement, and structural safety of the bridge. Issues developing from bearing movement can cause structural defects in other elements (e.g. a girder subject to settlement at one end).

#### Condition States

**Condition State 1** indicates there is no loss of bearing area.

**Condition State 2** indicates the loss of area is less than 10% of the total bearing area.

**Condition State 3** indicates the loss of area is 10% or more of the total bearing area but does not warrant a structural review.

**Condition State 4** indicates the loss of area is 10% or more of the total bearing area and requires a structural review to determine the effect of the defect on the strength or serviceability of the element or bridge or that a structural review has been completed and the loss of area impacts the strength or serviceability of the bridge.

## A.3.3 Joint Defects

### A.3.3.1 Leakage/Seal Adhesion/ Damage/Cracking (2310)

This defect is used to report leakage through or around sealed bridge joints. Water leakage through a joint can lead to deterioration and section loss of the surrounding elements as well as the elements below the joints. Leakage can also be detrimental to the substructure if unexpected water flow is allowed to enter the soil around the foundation.

This defect is also used to report loss of adhesion in sealed bridge joints. Sealed bridge joints will typically use a type of adhesive chemical (contact cement, joint adhesive, glue, etc.) to adhere the seal to the adjacent bridge deck or steel extrusion. Over time this glue could lose its adhesive properties and start to degrade which will allow the seal to pull away and permit leakage through the joint.

Seal damage is used to report damage to the seal gland in bridge joint seals. Since the seal is continually subject to the traffic that passes over the bridge deck there can be damage caused by incidental contact (snow plows, large vehicles, etc.) or debris impaction. This damage can lead to leakage through the joint and should be closely monitored by the inspector.

Seal cracking is used to report cracking in the seal gland in bridge joint seals. Plastic or polymer material tends to lose its elasticity after exposure to UV rays from the sun. As the bridge continues to expand and contract the seal will begin to degrade which can lead to cracking. Once cracking has initiated it can quickly propagate if left in a poor environment. The inspector should note any cracking of the seal as it can lead to leakage if not repaired or retrofitted.

Condition States

**Condition State 1** indicates that the joint is fully adhered.

**Condition State 2** indicates there is minimal leakage through the joint. Minimal leakage is defined as minor or occasional leaking or water from localized areas of a joint. The seal is adhered for more than 50% of the joint height. There is seal abrasion but without through punctures or cracks.

**Condition State 3** indicates there is moderate leakage through the joint. Moderate leakage is defined as multiple areas of leaking and passage of debris through the joint. The seal is adhered to 50% or less of the joint height but there is still some adhesion. The joint is punctured, cracked, ripped, or partially pulled out.

**Condition State 4** indicates the joint has failed and there is a free flow of water and debris through the joint. There is a complete loss of seal adhesion or the seal is punctured, cracked, or torn completely through, pulled out, or missing.

### A.3.3.2 Debris Impaction (2350)

Dirt, gravel and debris lodged in the joint may prevent normal expansion and contraction, causing cracking in the deck and backwall, and overstress in the bearings. In addition, as dirt and debris are continually driven into the joint, the joint material may eventually rupture or pull out.

#### Condition States

**Condition State 1** indicates there is no debris in the joint. A shallow covering of loose debris may be present but not affecting the performance of the joint.

**Condition State 2** indicates the joint is partially filled with hard-packed material but still allows for free movement and the joint can perform as expected.

**Condition State 3** indicates the joint is completely filled with debris, which has an effect on the movement and performance of the joint.

**Condition State 4** indicates the joint is completely filled with debris, which has completely prevented joint movement.

### A.3.3.3 Adjacent Deck or Header/Metal Deterioration or Damage (2360)

Many joints are connected to the deck utilizing some type of anchorage. The inspector shall examine deck areas adjacent to deck joints for material deterioration such as section loss, spalls, delaminations, and vehicular/snow plow damage. Deterioration of the deck in these areas may be an indication of problems with the anchorage. Metal deterioration or damage is used to report steel damage or deterioration in the bridge joint (such as a finger joint, sliding plate joint, or steel extrusions of a seal joint). This will include corrosion, section loss, and cracking that have occurred through other means besides impact damage.

#### Condition States

**Condition State 1** indicates the adjacent deck or header is sound. No spalling, delamination, metal deterioration or damage, or unsound patches are present.

**Condition State 2** indicates there is edge delamination or spalls less than 1 in. deep or less than 6 in. in diameter. There are no exposed rebar in any present spalls and any patched areas are sound. Freckled rust may be present but the metal has no cracks, or impact damage. The connection may be loose but is still functioning as intended.

**Condition State 3** indicates there is edge delamination with spalls greater than 1 in. deep or 6 in. in diameter. Spalls may have exposed rebar. Delamination or unsound patched areas or delaminations are present that make the joint loose. There is section loss, missing or broken fasteners, cracking of the metal, or impact damage but the joint is still functioning.

**Condition State 4** indicates there are spalls, delaminations, unsound patched areas, or loose anchors which prevent the joint from functioning as intended. There is also metal

cracking, section loss, damage, or connection failure that prevents the joint from functioning as intended.

## A.3.4 Steel Protective Coating Defect

### A.3.4.1 Oxide Film Degradation Color/Texture Adherence – Weathering Steel (3430)

This defect is the only defect used to report oxide film degradation of texture in Weathering Steel. Weathering steel can be an effective steel protective coating if allowed to corrode as designed. If weathering steel is placed in an environment with substantial moisture then the steel will continue to corrode and lead to section loss of the steel. The inspector should note the color and pitting or section of the steel as these can be an indication of the health of the element.

Condition States

**Condition State 1** indicates oxide film with a yellow-orange or light brown for early development, or a chocolate-brown to purple-brown for fully developed films. The oxide film is tightly adhered and capable of withstanding hammering or vigorous wire brushing.

**Condition State 2** indicates an oxide film which has developed a granular texture.

**Condition State 3** indicates an oxide film which has developed small flakes that are less than ½ in. diameter.

**Condition State 4** indicates an oxide film with dark black color. The film has large flakes which are ½" in. or larger in diameter. The film may have developed laminar sheets or nodules.

### A.3.4.2 Effectiveness (3440)

This defect is the only defect to be used on all steel protective coatings other than Weathering Steel. The ability for the protective coatings to protect the steel element it is placed over is its effectiveness. A protective coating can lose effectiveness through wear, deterioration, and leakage.

Condition States

**Condition State 1** indicates a protective coating which is fully effective. Coating system may have minor fading, chalking, dulling, but there is no active corrosion and primer coat is intact.

**Condition State 2** indicates a protective coating which is substantially effective. Coating system may have moderate deterioration such as chalking, peeling, blistering or cracking to finish coat. Surface/freckle rust or staining may be present, but there is no pack rust.

**Condition State 3** indicates a protective coating which is limited effectiveness. Coating system has extensive deterioration to finish and primer coats. There is loss of pigment, peeling, bubbling, or cracking to finish and primer coats. Surface rust is prevalent. Pack rust may be present.

**Condition State 4** indicates a protective coating which has failed or is non-existent and provides no protection of the underlying metal. There may be heavy corrosion and pack rust.

## A.3.5 Wearing Surface Defects

### A.3.5.1 Debonding/Spall/Patched Area/Pothole – Wearing Surface (3210)

Debonding is the result of lost bond between the overlay surface and the bridge deck below. This defect can occur in any type of overlay material. Once debonded, cyclical loading cycles, such as traffic, freeze/thaw, expansion and contraction will eventually deteriorate the delamination enough to failure. This can often lead to spalling of the wearing material. Spalls result from the separation and removal of a portion of the surface material, revealing a fracture roughly parallel to the surface. When spalls occur on the riding surface they are considered potholes. Inspectors should use sketches showing the location and dimensions of delaminations and spalls. The depth of spalls should also be recorded. When a spall exposes steel reinforcing, the wearing surface in that area is no longer considered effective and shall be coded Condition State 4.

Condition States

**Condition State 1** indicates that no debonding, spalls, patched areas, or potholes exist.

**Condition State 2** indicates that the wearing surface is debonding, has spalls less than 1 inch deep or less than 6 inches in diameter, has sound patched areas, or has partial depth potholes.

**Condition State 3** indicates that the wearing surface is debonded, has spalls greater than 1 inch deep or more than 6 inches in diameter, has unsound patched areas that may be showing distress, or has full depth potholes.

**Condition State 4** indicates that debonding, spalls, patched areas, or potholes have made the wearing surface no longer effective.

### A.3.5.2 Crack – Wearing Surface (3320)

A crack is a linear fracture in the overlay material. Cracking can extend partially or completely through the wearing surface. There are two types of cracking; structural and nonstructural. Structural cracks are due to the loads imposed on the wearing surface and nonstructural cracks are due to temperature, shrinkage, and mass concrete.

Condition States

**Condition State 1** indicates that cracks in the wearing surface are less than 0.012 inches or there are sealed cracks.

**Condition State 2** indicates that cracks in the wearing surface are between 0.012 and 0.05 inches.

**Condition State 3** indicates that cracks in the wearing surface are greater than 0.05 inches.

**Condition State 4** indicates that cracking have made the wearing surface no longer effective.

## A.3.5.3 Abrasion, Wear, Rutting, or Loss of Friction – Wearing Surface (8911) [ADD]

This defect captures how well the wearing surface is handling vehicular traffic. Over time, the wearing surface will undergo several changes in its ability to handle traffic. Abrasion and wear are similar in that the wearing surface is starting to degrade and is not of its original thickness, or the surface material is starting to be removed. Rutting occurs in the wheel paths of the travelled way. This can be caused by either the removal of the material in the wheel paths, or due to the wearing surface material not being able to withstand the traffic. Eventually the wearing surface material will begin to compress/shift to the adjacent area that is not carrying traffic. Typically, rutting will also have cracking associated with it due to the wearing surface material movement. Loss of friction can be created by the removal of the surface binder, which exposes the smooth aggregate. When vehicles ride on the smooth aggregate in adverse weather conditions, the coefficient of friction is reduced between the vehicle tire and the wearing surface.

### Condition States

**Condition State 1** indicates that there is no abrasion, wear, rutting, or loss of friction.

**Condition State 2** indicates that there is minimal loss of surface material in wheel paths. There is no significant loss of friction. The asphalt overlay is exhibiting minor isolated rutting.

**Condition State 3** indicates that there is a loss of surface material which has become prevalent in the wheel paths. The loss of friction is noticeable and/or the asphalt overlay has moderate to severe isolated rutting.

**Condition State 4** indicates that there is widespread loss of surface material throughout the overlay. Exposed reinforcing may be present with or without corrosion or section loss. The loss of friction is prevalent and potentially dangerous in adverse weather conditions. The asphalt overlay has significant rutting throughout the length of the structure.

## A.3.6 Concrete Reinforcing Steel Protective System Defects

### A.3.6.1 Effectiveness – Protective System (e.g. cathodic) (3600)

This defect is used to report the effectiveness of internal concrete protective systems (cathodic protection). The ability for the protective coating to protect the concrete element it is placed within is its effectiveness.

Condition States

**Condition State 1** indicates that the coating is fully effective.

**Condition State 2** indicates that the coating is still substantially effective.

**Condition State 3** indicates that the coating has limited effectiveness.

**Condition State 4** indicates that the protective system has failed or is no longer effective.

## A.3.7 Concrete Protective Coating Defects

### A.3.7.1 Effectiveness - Concrete (3540)

This defect is used to report the effectiveness of external concrete protective systems. The ability for the protective coating to protect the concrete element it is placed over is its effectiveness. A protective coating can lose effectiveness through wear, deterioration, and leakage.

Condition States

**Condition State 1** indicates that the coating is fully effective.

**Condition State 2** indicates that the coating is still substantially effective.

**Condition State 3** indicates that the coating has limited effectiveness.

**Condition State 4** indicates that the protective system has failed or is no longer effective.

## A.3.8 Strengthening/Repair System Defects

### A.3.8.1 Deterioration (1220)

Deterioration can be considered the material breakdown of the element. This may include cracking, corrosion, section loss, discoloration, debonding, etc. It encompasses the deterioration defects of all materials. This defect is only to be used for FRP and Culvert Liner.

Condition States

**Condition State 1** indicates that there is no deterioration occurring.

**Condition State 2** indicates that the FRP or culvert liner has initiated breakdown or deterioration.

**Condition State 3** indicates that there is significant deterioration or breakdown, but it does not warrant a structural review.

**Condition State 4** indicates that the deterioration or breakdown has become severe enough to warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the deterioration or breakdown impact strength or serviceability of the element or bridge.

### A.3.8.2 Distortion (1900)

This defect is used to report distortion from the original line or grade of the element. It is used to capture all distortion regardless of cause. This defect is used for FRP and Culvert liner only.

Condition States

**Condition State 1** indicates no distortion.

**Condition State 2** indicates there is distortion that does not require mitigation or previously reported distortion which has been mitigated.

**Condition State 3** indicates there is distortion present which requires mitigation but does not warrant a structural review.

**Condition State 4** indicates there is distortion present which requires mitigation and warrants a structural review to determine the strength or serviceability of the element or a structural review has been completed and the distortion impacts the strength or serviceability of the bridge.

### A.3.8.3 Delamination/Spalls/Patched Areas (1080)

Delamination is the result of a loss of bond between concrete and rebar due to expanding corrosion product of corroded reinforcement and can often lead to spalling of the concrete. Spalling is a depression in concrete where sections of concrete separate from aggregate or the reinforcement. Spalls result from the separation and removal of a portion of the surface concrete, revealing a fracture roughly parallel to the surface. Inspectors should use sketches showing the location and dimensions of delaminations and spalls. The depth of spalls should also be recorded. This defect is used only for jacketing and external post tensioning only.

#### Condition States

**Condition State 1** indicates that there are no apparent delaminations, spalls, or patched areas.

**Condition State 2** indicates that there are delaminated and/or spalled areas that are less than 1” deep or less than 6” in diameter or in either the length or width dimension. . Any patched areas are sound.

**Condition State 3** indicates that there are spalled areas that are greater than 1” deep or greater than 6” in diameter, or in either the length or width dimension. Patched areas are unsound or showing distress. The delamination, spall, or patched area does not warrant a structural review.

**Condition State 4** indicates that the depths of delaminations, spalls, or patched areas warrant a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.3.8.4 Exposed Rebar (1090)

Exposed rebar can be the result of spalls, delaminations, or damage. Exposed rebar will be susceptible to accelerated corrosion and deterioration due to its exposure to the environment. Inspectors should record the area and location of corrosion to reinforcement and record any measureable section loss. This defect is used only for jacketing and external post tensioning only.

#### Condition States

**Condition State 1** indicates that there is no exposed rebar in the bridge member.

**Condition State 2** indicates that rebar is exposed and surface corrosion may be present but without section loss.

**Condition State 3** indicates that rebar is exposed and surface corrosion is present with measurable section loss but does not warrant a structural review. Caliper/thickness gauge measurements should be used to determine the amount of section loss.

**Condition State 4** indicates that rebar is exposed and surface corrosion is present with measurable section loss and warrants a structural review to determine the effect on

strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge. Caliper/thickness gauge measurements should be used to determine the amount of section loss

### A.3.8.5 Cracking – Reinforced Concrete (1130)

Cracking is common in reinforced concrete due to concrete's lack of strength in tension. Cracking can be a result of structural forces, temperature, or other forces. Common locations for structural cracking include negative moments over a support, near supports from shear stress, and the bottom of elements near mid-span from positive moments. Temperature cracking is caused by thermal expansion and contraction. Shrinkage cracks are due to the shrinkage of concrete caused by the curing process. It can cause either pattern (map) cracking or random cracks. Mass concrete cracks occur due to thermal gradients, the differences between interior and exterior temperatures, in massive sections immediately after the placement and for a period of time afterwards. While all cracking allows moisture and chemicals to infiltrate the concrete, structural cracking is considered more critical as it could be a result of a larger issue. Inspectors should note all visible cracks, recording their type, width, length, and location. This defect is used only for jacketing and external post tensioning only.

Condition States

**Condition State 1** indicates that there is cracking present less than 0.012" wide or any cracks larger are sealed.

**Condition State 2** indicates that there is cracking present between 0.012" and 0.05" wide. Where efflorescence is present, it's minor and there is no evidence of rust staining.

**Condition State 3** indicates that there is cracking greater than 0.05" wide. Where efflorescence is present there is heavy build-up and/or rust staining.

**Condition State 4** indicates the cracking warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

## A.3.8.6 Corrosion (1000)

Section loss of steel is caused by corrosion heavy or severe enough to physically measure a reduction in member thickness.

The inspector should look for areas of laminate rust on the steel surface or areas of heavy blistering paint (caused by a build-up of rust under the paint surface). Common locations are horizontal surfaces, areas subject to salt spray from roads or areas near water surfaces. The most effective tools used to remove the laminate rust are chipping hammers and paint scrapers. Severe corrosion will usually consist of fairly loose, brown laminate rust, and a hard, tightly adhered black corrosion product on the base metal surface. A chipping hammer is usually required to remove this black corrosion. Safety glasses should always be worn when using a chipping hammer.

Once the corrosion has been removed, the amount of remaining section should be measured and recorded. Methods to measure the remaining section include the use of a caliper, a micrometer or ruler with a straight edge spanning the depression to indicate the original steel surface. The surface area affected by the corrosion should also be measured.

Some corrosion is so severe that holes are created through the steel. This situation should be recorded as “through thickness section loss” rather than “100 percent section loss” since the latter term suggests that the entire member or element has corroded away. This defect is used only for jacketing and external post tensioning only.

### Condition States

**Condition State 1** indicates no corrosion exists or it has been repaired and painted over corrosion that has been painted over will not prevent further corrosion from occurring and should not be considered a Condition State 1. Repairs suggest that the member or element has been retrofitted so that it has its original load-carrying capacity. The repairs may be in the form of bolted splices or welded splices.

**Condition State 2** indicates that corrosion of the steel has initiated or freckled rust is present.

**Condition State 3** indicates that section loss or pack rust exists. If the condition is not repaired/ rehabilitated, a structural analysis may be warranted in the near future. The inspector should consider recommending cleaning and painting of the member to help prevent further section loss.

**Condition State 4** indicates that excessive section loss exists, and that structural analysis results indicate member capacity or serviceability is compromised.

### A.3.8.7 Cracking – Steel (1010)

Steel cracking addresses fatigue cracks, regardless if they occur within a fracture critical or non-fracture critical bridge. Cracking in substructure elements will most often occur in steel pier caps or cross girders. Any cracks not previously detected should be evaluated to determine the potential for fracture.

Inspectors should be especially thorough at details which are prone to developing fatigue cracking. Refer to Appendix D for a list of fatigue details. Detection of these cracks will most often occur during In-Depth or Fracture Critical Inspections but can still be found during Routine Inspections as well. Any crack defects classified as a Condition State 3 or worse should be immediately reported to the Inspection Program Manager. Serious consideration should be given to closing the bridge until the extent and cause of cracking is determined and appropriate remedial action is taken. This defect is used only for jacketing and external post tensioning only.

#### Condition States

**Condition State 1** indicates that no cracking exists in the member.

**Condition State 2** indicates that a crack exists, but it has either been arrested by drilling holes at the tips or it has been repaired with bolted splices or welded splices. Shallow or short cracks may also be ground out. Unrepaired, self-arrested, or cracks not arrested with drilled holes may also fall into this Condition State, but they are located in a non-critical or redundant member.

**Condition State 3** indicates that a crack which has not been arrested or repaired exists in a primary load-carrying member, including newly-discovered crack or existing cracks that are still growing between inspection cycles. Cracks of this nature suggest it is fatigue related, stable crack growth.

**Condition State 4** indicates that a very large crack exists in any primary load-carrying member. Newly-discovered cracks are greater than 3 inches in length, or existing cracks have grown more than 6 inches within the last 24 months. Cracks of this nature suggest they developed in an uncontrolled brittle fashion.

### A.3.8.8 Connection (1020)

Connections can be constructed from two or more members or elements that may be bolted, riveted, or welded together. Connection deficiencies include any deterioration or damage of fasteners, such as rivets, bolts, or welds and connection plates (gusset plates). Any suspected loose or deteriorated fasteners should be struck with a hammer to determine soundness. Welded connections should be visually inspected for fatigue cracks developing from weld imperfections or overstress. Connections are also often subjected to distortion due to pack rust (corrosion occurring between two pieces of lapped steel). The amount of separation caused by pack rust and any distortion to the steel should be measured and recorded. This defect is used only for jacketing and external post tensioning only.

Condition States

**Condition State 1** indicates that the connection is in place and is functioning as intended.

**Condition State 2** indicates that there are loose fasteners and/or pack rust without distortion. The connection is in place and functioning as intended despite these defects.

**Condition State 3** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. Although these defects are present, the structural capacity of the structure is not reduced.

**Condition State 4** indicates that there are missing bolts, rivets, broken welds, fasteners, and/or pack rust with distortion. These defects reduce the structural capacity of the member assembly.

### A.3.8.9 Cracking – Prestressed Concrete (1110)

Concrete cracks might indicate a significant loss in strength in prestressed concrete members. Loss of prestress due failure of prestressing steel may result in a serious defects manifested in loss of camber, beam sag, and/or wide structural cracks. Inspectors should note all visible cracks, recording their type, width, length, and location. This defect is used only for jacketing and external post tensioning only.

Condition States

**Condition State 1** indicates that there is cracking present less than 0.004” wide or any wider cracks are sealed.

**Condition State 2** indicates that there is cracking present between 0.004” and 0.009” wide. Where efflorescence is present, it’s minor and there is no evidence of rust staining.

**Condition State 3** indicates that there is cracking present greater than 0.009”. Where efflorescence is present, there is heavy build up or rust staining.

**Condition State 4** indicates that there is cracking which warrants a structural review to determine the effect on strength or serviceability of the element or bridge, or a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

## A.3.8.10 Abrasion/Wear (1190) (PSC/RC)

Vehicular traffic is a source of abrasion and wear on concrete decks. Abrasion occurs on concrete piles that are subjected to flowing water or tidal flows. Mechanical wear of concrete members sometimes occurs due to movement of the fasteners against their holes when connections become loose. This defect is used only for jacketing and external post tensioning only.

### Condition States

**Condition State 1** indicates no abrasion.

**Condition State 2** indicates abrasion has exposed coarse aggregate but the aggregate remains secure in the concrete.

**Condition State 3** indicates coarse aggregate is loose or has popped out of the concrete matrix due to abrasion.

**Condition State 4** indicates the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

### A.3.9 Wall Defects

Wall defects can be found in Part 4 of this manual.