

PART 2 – DETAILED VISUAL INSPECTION

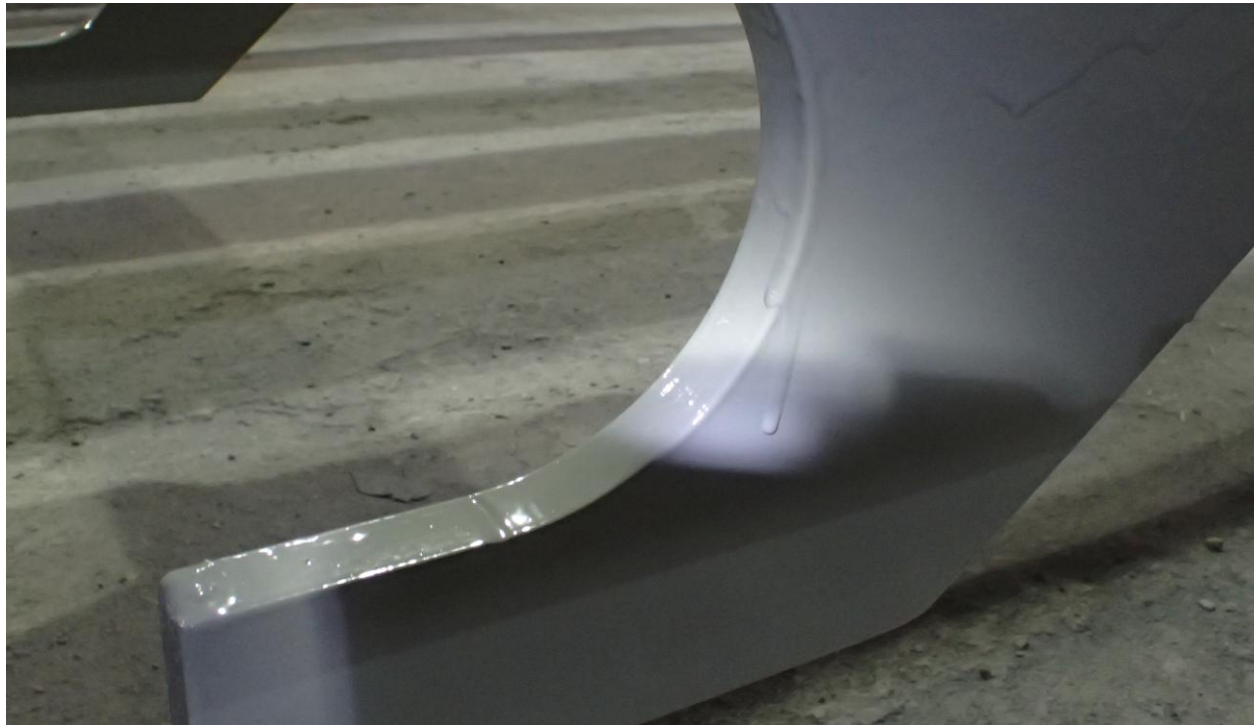


Figure 2.5.5.11 Runs and Sags

PINPOINT RUSTING usually occurs when insufficient thickness of coating is applied over a blast cleaned substrate. The profile peaks lack proper protection and continue to rust.

2.5.5.4 Defect Table

Table 2.5.4.1 Coating Defect Definitions

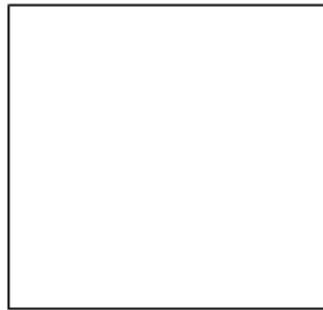
DEFECT		CONDITION STATE		
		GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Rust Condition Rating		Rust condition rating is a visual rating of the surface appearance and is based on ASTM D610 sketches and is also shown in Figure 2.5.5.12 Rust Condition Rating Categories for Coatings		
		Rust Condition Rating 2	Rust Condition Rating 3	Rust Condition Rating 4 or more
Coating-Related	Checking or Cracking	Fine system of minute cracks in a checkerboard pattern. Caused by weathering and exposure during curing		
			ALL	
	Cracking	Linear pattern of crack penetrated through coating. Results from weathering, continuing polymerization or shrinkage		
			ALL	

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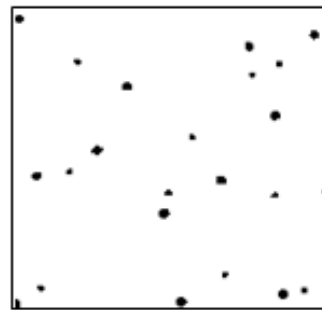
	Alligatoring	Large irregular checks across surface. Caused by non compatible layers of coating and hardening/shrinkage process		ALL	
	Chemical Attack	Coating reacting adversely with air borne chemicals or accidental spills		ALL	
	Chalking	Powdery appearance of coating surface. Caused by reaction of coating resins to sunlight and process of weathering.		ALL	
Adhesion-Related Defects	Undercutting	Spreading of corrosion under coating from a break. Caused by poor surface preparation			ALL
	Blisters	Dome shaped projections of coating. Caused by solvent or water trapped within paint film			ALL
	Intercoat Delaminations	One coat separates from another. Caused by contaminated surfaces or excessive curing between coats		ALL	
Peeling	Separation of coating from steel due to poor adhesion			ALL	
Underfilm Corrosion	Corrosion under the coating with the help of from a break. Caused by poor preparation or porous coating			ALL	
Application-Related Defects	Bridging	Coating bridges across tight corner or debris forming void. Void can trap moisture and oxygen		ALL	
	Edge Defects	Coating pulls away from sharp edges and corners. Due to insufficient application of coating at edge		ALL	
	Shadows	Coating is applied too thin in the shadow of a rivet, bolts, or other abrupt change in surface		ALL	
	Overspray	Some paint particle outside spray pattern dry prior to full coating. Leads to some absorbed solvent and a more porous surface		ALL	
Pin holing	Air bubbles trapped in coating creating voids. Caused by holding spray gun too close		ALL		
Runs	Downward movement of paint. Caused by over-thinning or depositing too much paint at one time		ALL		
Sags	Like runs, the downward movement of 'curtain' of paint		ALL		

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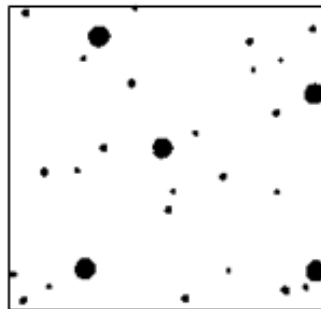
	Pinpoint Rusting	Rusting visible at point locations. Caused by insufficient coating thickness on peaks of blast cleaned substrate
		Rate based on appearance and Rust Condition Ratings.



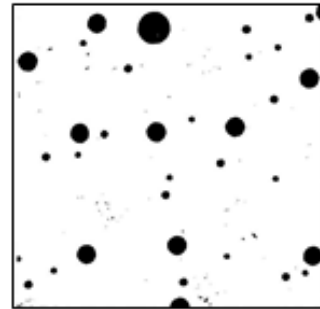
Condition State: Excellent
Category 1: No Rust



Condition State: Good
Category 2: Light Surface Rust



Condition State: Fair
Category 3: Medium Surface Rust



Condition State: Poor
Category 4: Severe Surface Rust

Figure 2.5.5.12 Rust Condition Rating Categories for Coatings

2.5.6 Steel – Substructures and Superstructures

This section describes steel material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.5), then followed by photos to visually show sample defects.

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The use of steel has progressed from cast iron, wrought iron, rivet steel and plain carbon steel to low alloy atmospheric corrosion resistant steel (weathering steel) and notch tough low temperature steel.

The following defects commonly occurring in steel are described:

- Corrosion.
- Permanent Deformation.
- Cracking.
- Connection deficiencies.

2.5.6.1 Corrosion

Corrosion is the deterioration of steel by chemical or electro-chemical reaction resulting from exposure to air, moisture, de-icing salts, industrial fumes and other chemicals and contaminants in the environment in which it is placed. The terms rust and corrosion are used inter-changeably in this sense. Corrosion, or rusting, will only occur if the steel is not protected or if the protective coating wears or breaks off.

Rust on carbon steel is initially fine grained, but as rusting progresses it becomes flaky and delaminates exposing a pitted surface. The process thus continues with progressive loss of section.

Weathering steel, on the other hand, will form a relatively smooth rust layer, called a patina, which protects the underlying metal from further corrosion. However, in less than ideal circumstances, the patina may not form or may be penetrated and delaminated, resulting in progressive corrosion (References 2,3).

For weathering steel to form a tightly adherent patina, the following conditions must be met:

- the steel must be exposed to intermittent wetting and drying cycles.
- corrosive contaminants, especially salt bearing water, must be absent.
- the steel surfaces must be kept clean and free of entrapped dirt, debris and moisture.

In addition to the above, mill scale is often left on weathering steel to "weather off", except where it is removed for appearance; however, if the mill scale is scratched, then the underlying metal may corrode.

Corrugated Steel Pipe culverts (CSP's) and multi-plate culverts experience rusting after the protective galvanizing coating has worn off. This rusting is often most prevalent near the waterline where the abrasive action of the water prematurely wears away the coating and the steel is subject to high humidity.

Corrosion in steel is illustrated in Figure 2.5.6.1 and Figure 2.5.6.2.

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Figure 2.5.6.1 Medium Corrosion of Steel Beam



Figure 2.5.6.2 Severe Corrosion of Steel Beam

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Microbial-Induced Corrosion:

Microbial-induced corrosion (MIC) is a form of localized, rapid corrosion that can occur at or below the water. MIC consists of microorganisms that, through their biological processes, cause elements to corrode at an accelerated rate. Cases have been documented where MIC has accelerated corrosion by as much as ten times the normal rate.

A bright orange sulfurous deposit on the steel near the waterline indicates the possible presence of MIC, but it must be removed to test and confirm the presence of MIC. The orange deposits can generally be easily removed by wiping with a gloved hand. When removed, there will be a layer of gray, black, often flakey, corrosion product of iron sulfide. If the iron sulfide is removed, the underlying steel is generally pitted and shiny.

2.5.6.2 Permanent Deformation

Permanent deformation of steel members can take the form of bending, buckling, twisting or elongation, or any combination of these. Permanent deformations may be caused by overloading, vehicular collision, or inadequate or damaged intermediate lateral supports or bracing. See Figure 2.5.6.3.



Figure 2.5.6.3 Severe Deformations Caused by Impact

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Permanent bending deformations occur in the direction of the applied loads and are usually associated with flexural members; however, vehicular impact may produce permanent deformations in bending in any other member.

Permanent buckling deformations normally occur in a direction perpendicular to the applied load and are usually associated with compression members. Buckling may also produce local permanent deformations of webs and flanges of beams, plate girders or box girders.

Permanent twisting deformations appear as a rotation of the member about its longitudinal axis and are usually the result of eccentric transverse loads on the member.

Permanent axial deformations occur along the length of the member and are normally associated with applied tension loads.

In Corrugated Steel Pipe culverts (CSP's) and Multi-Plate culverts some degree of deformation can be tolerated due to the continuity of the steel plate along the culvert length. Deformations in culverts can include the following:

- **Cusping:** The abrupt change in curvature of the culvert wall, typically at a longitudinal seam, leading to a lifting of adjacent plates and usually caused by improper installation of bolts (lack of torque) or poor backfill compaction. Cusping usually leads to other defects since the culvert is not in its design shape and significant bending stresses can occur.
- **Crimping:** The local buckling of culvert wall (usually near areas of higher curvature) primarily due to bending forces.
- **Bolt Tilting:** The bearing failure of the culvert wall at the location of the bolt holes. Initially, the bolts tilt as the inner and outer plates of the culvert move against each other. As it progresses, it often leads to cracking at the bolt holes.
- **Global Deformations:** These distortions usually occur on the roof or sometimes on the floor of the culvert. It is caused by the weight of soil or live load when the roof deforms or due to soil or hydrostatic pressures from below when the floor deforms. Often, it is caused by improper installation and the deformation can be tolerated if the movement has stabilized – this should be ascertained by monitoring. It is more serious when there is reverse curvature of the culvert. The culvert wall relies on its curved shape to maintain the internal forces as primarily axial thrust (and not bending) and the wall relies on curvature into the soil to provide lateral support for the culvert wall in compression.

2.5.6.3 Cracking

CRACK is a linear fracture in the steel. Cracks are mainly produced due to fatigue and can, under certain conditions, lead to a brittle fracture.

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BRITTLE FRACTURE is a crack completely through the component that usually occurs without prior warning or plastic deformation. Brittle fracture may result at fatigue prone details after initial fatigue cracking. Other cases of brittle fracture have occurred due to a phenomenon known as constraint induced fracture (CIF). This type of fracture typically occurs when two or more welds pass close to (within 6 mm) each other or intersect. Fracture often occurs with no warning. It is critical during inspections to identify details that may be susceptible to CIF to assess the detail and determine retrofit requirements.

FATIGUE PRONE DETAILS are those details that are susceptible to the growth of fatigue cracks. Fatigue cracks are caused by either load-induced fatigue or by distortion-induced fatigue. Load-induced fatigue is especially problematic for stress categories E and E1 (illustrated in References 9 and 10). Distortion-induced fatigue cracking accounts for about 80% of the fatigue cracks found on bridges. Structures constructed prior to the 1990's typically have connection details that are vulnerable to distortion-induced fatigue.

FRACTURE CRITICAL COMPONENTS are components which are subject to tensile stresses in a single load path structure and whose failure could lead to collapse of the structure. Any attachment having a length in the direction of tension stress greater than 100 mm and that is welded to the tension area of a fracture critical component shall also be considered as fracture critical.

The primary factors leading to fatigue cracking are the number of applied stress cycles, which is a function of the volume of traffic; the magnitude of the stress range, which depends on the applied live load; and the fatigue strength of the connection detail, category A to E1, as given in the Canadian Highway Bridge Design Code, Reference 10. Cracks caused by fatigue usually occur at points of tensile stress concentrations, at welded attachments, or at termination points of welds. Cracks may also be caused or aggravated by overloading, vehicular collision or loss of section resistance due to corrosion. In addition, stress concentrations due to the poor quality of fabricated details and the fracture toughness of materials used are contributing factors. Material fracture toughness will determine the size of crack that can be tolerated before fracture occurs.

Welded details are more prone to cracking than bolted or riveted details. Grinding off the weld reinforcement to be smooth or flush with the joined metal surfaces improves fatigue resistance. Once cracking occurs in a welded connection, it can extend into other components due to a continuous path provided at the welded connection, and possibly lead to a brittle fracture.

Bolted or riveted connections may also develop fatigue cracking, but a crack in one component will generally not pass through into the others. Bolted and riveted connections are also susceptible to cracking or tearing resulting from prying action, and by a build-up of corrosion forces between the parts of the connection.

Cracking in a gusset plate is shown in Figure 2.5.6.4.

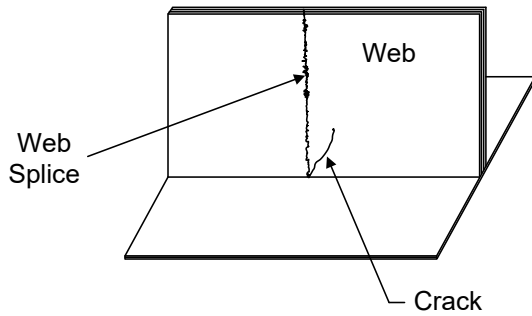
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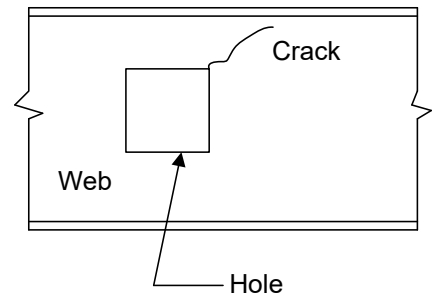
Figure 2.5.6.4 Cracks in Gusset Plate

Common locations susceptible to fatigue cracking are illustrated in Figure 2.5.6.5 and Figure 2.5.6.6. As cracks may be concealed by rust, dirt or debris, the suspect surfaces should be cleaned prior to inspection.

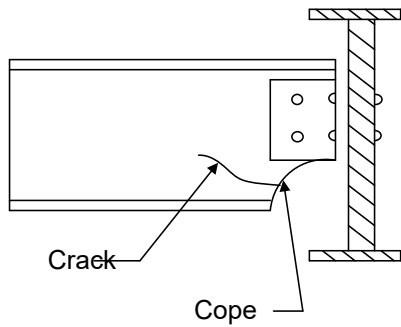
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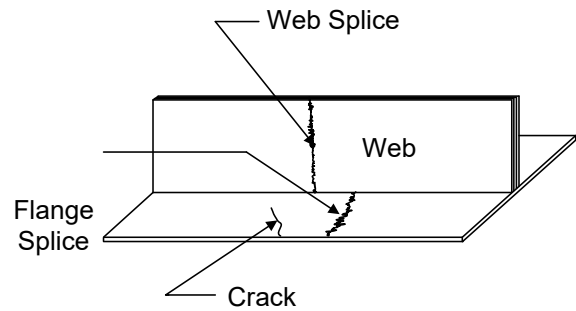
Crack in Web at Web Splice



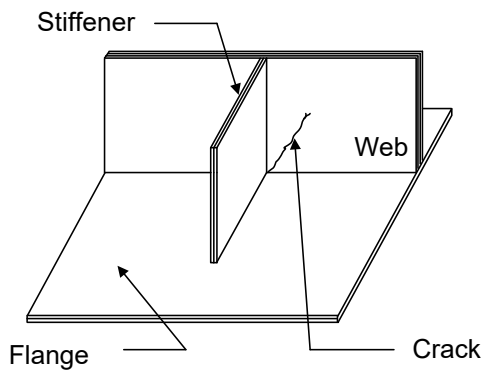
Crack at Hole in Web



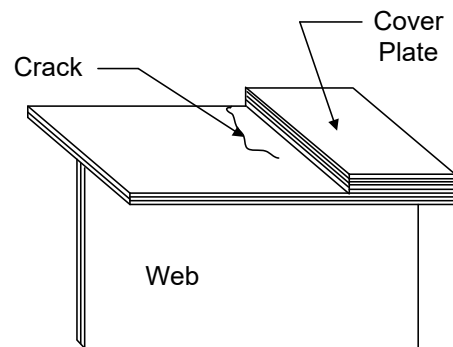
Crack in Cope of Web at a Connection



Crack in Flange at Flange Splice



Crack in Web at Stiffener



Crack at End Weld of Flange Cover Plate

Figure 2.5.6.5 Common Crack Locations in Steel

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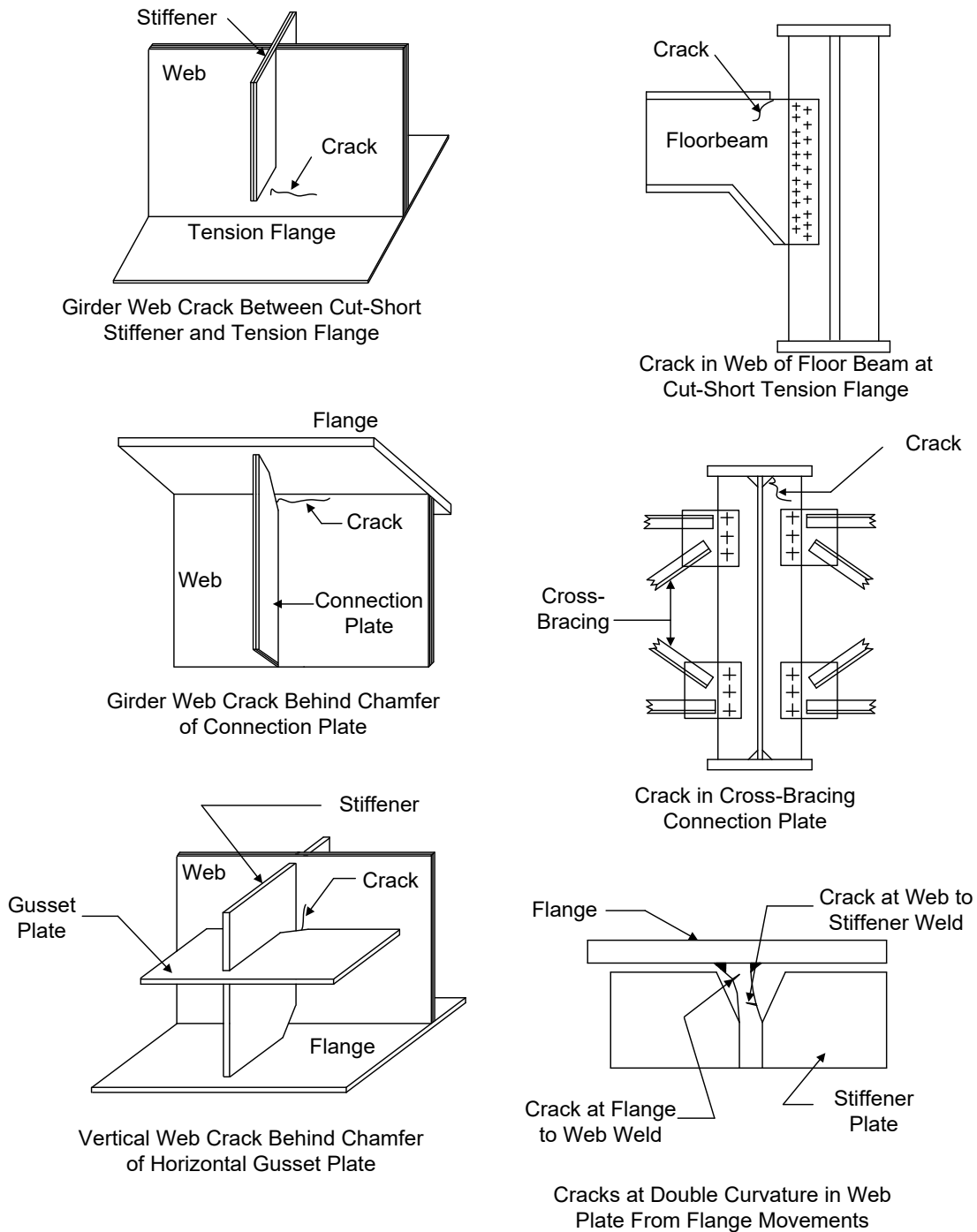


Figure 2.5.6.6 Common Crack Locations in Steel (cont.)

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In corrugated steel pipe culverts (CSP's) and multi-plate culverts some degree of cracking at bolt hole locations may be tolerated due to the continuity of the steel plate along the culvert length. For this reason, cracks at bolt holes may not require repair as urgently as cracks in steel bridge members. These cracks can occur due to improper installation or due to higher bending or compressive forces in the culvert walls.

2.5.6.4 Connection Deficiencies

Loose connections can occur in bolted, riveted or clamped connections. The loose condition may be caused by corrosion of the connector, gusset plates or fasteners, cracking or failure of the individual fasteners, excessive vibration, over stressing, or simply a lack of proper tightening during construction.

Loose connections may not always be detectable by visual or hands-on inspection, as the looseness may only appear during serviceability loading. Cracking or excessive corrosion of the connector or gusset plates or the fasteners, as well as permanent deformation of the connection or members framing into it, may be indications of loose connections. Also, fasteners with missing washers or improper thread engagement are more susceptible to becoming loose over time and should be inspected more closely. Tapping the connection with a hammer is one method of determining if the connection is loose.

The other deficiencies typically associated with connections are corroded or cracked connectors or gusset plates.

The severity of the connection deficiency shall be based on the condition of the worst component within the connection. This means that the connection will be rated based on the looseness or corrosion of the worst component. In the case of truss members, the connection shall be taken as the entire joint or node location, including both gusset plates in and out of plane, with all members that frame in. All connecting member plates shall be inspected with the overall connection rating based on the worst of these components. For Bailey bridges, the Bailey panel connection pin shall be rated as a connection. The other connections, such as transom clamps and raker pins are too numerous to rate individually. They still should be inspected, but problems should be noted as either a maintenance need or a performance deficiency (as described in Part 2, Section 2.6 below and 2.7 below) for the floor beam or truss bracing elements respectively.

The location of the loose or missing fasteners, as well as areas of corrosion on gusset plates, should be described.

2.5.6.5 Defect Tables

Table 2.5.5.1: Steel Defect Definitions

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)

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Corrosion	Deterioration of steel by chemical/electro-chemical reaction resulting from exposure to air, moisture, de-icing salts, industrial fumes and other chemicals/contaminants in the environment in which it is placed		
	No section loss, loose rust/pitting– in paint -	< 10% section loss, small scales or flakes -	> 10% section loss, extensive rust/perforations *
	Early signs of patina damage	Flaking of patina	
Permanent Deformations	Steel members can take the form of bending, buckling, twisting or elongation.		
	Corrugate Steel Pipe (CSP) culverts can exhibit cusping (abrupt change in curvature, typically at seam), crimping (local buckling of culvert wall), global deformation (change in original curved shape), and bolt tilting (bearing failure of bolts).		
			For members: ALL (Estimate repair area) *
		Cusping or crimping of culverts <10mm in height.	Cusping or crimping of culverts >10mm in height *
	Global Deformation <10% of culvert diameter	Global Deformation >10% of culvert diameter and reverse curvature *	
	Bolt Tilting		
Cracking	Are linear fracture in the steel extending partially or completely through the member. They are mainly caused by fatigue, which can lead to brittle fracture (member cracks completely) through without prior warning)		
	<i>Cracks perpendicular to stress are very serious and should have immediate action taken.</i>		ALL * (Estimate repair area)
Connection Deficiencies	Loose connections can occur in bolted, riveted or clamped connections. They may be caused by corrosion of the connector, gusset plates or fasteners, excessive vibration, overstressing, cracking, or the lack of proper tightening during construction.		
	Based on the condition of the worst component within the connection		
	Depends on percentage of Loose Bolts or Plan Area with severe corrosion		
	< 5% loose bolts or severe rust	< 10% loose bolts or severe rust or cracks	> 10% loose bolts or severe rust or cracks

* For CSP culverts, all portions in the Poor Condition State except corrosion without perforations (i.e., cusping, crimping, deformations, cracks, and corrosion with perforations) the area shall be taken to include the entire circumference

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Table 2.5.6.1 Atmospheric Corrosion Resistant Steel Defect Definition

Defects	Good Condition	Fair Condition	Poor Condition
Patina conditions	Early signs of flaking but no section loss	Flaking and delamination with up to 10% section loss	More than 10% section loss.

2.5.7 Aluminum

This section describes aluminum material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.7.), then followed by photos to visually show sample defects.

Aluminum is often used in railings, splash guards, drainage systems, signs, and sign supports. The following defects commonly occurring in aluminum are described:

- Corrosion.
- Cracking.
- Connection deficiencies

2.5.7.1 Corrosion

Corrosion in aluminum is usually a uniform, gradual oxidation of the surface in the presence of air and moisture. Aluminum has a strong resistance to corrosion deterioration after the initial formation of aluminum oxide, a dense and very adherent film, which protects the underlying metal and inhibits further corrosion.

However, in less-than-ideal circumstances this protective layer may fail to form or be penetrated and broken down to expose the underlying metal. The process of corrosion will then continue with progressive loss of section.

Factors which affect this are the presence or exposure of the aluminum to de-icing salts, industrial fumes, water containing dissolved chemicals, bird droppings and surface scratches. Tight corners, especially around joints and connections, which entrap moisture and debris are, particularly, susceptible to progressive corrosion. In addition, contact with other metals and concrete results in galvanic and chemical corrosions.

GALVANIC CORROSION occurs at bi-metal joints. Where aluminum comes in contact with other metals a galvanic cell is formed in the presence of an electrolyte, such as a salt solution, resulting in the localized corrosion of the aluminum. Galvanic corrosion may affect the formation of the protective aluminum oxide film or cause the film to flake off. It is, therefore, necessary that an inert spacer, either nylon or neoprene, be placed between the two metals to prevent galvanic

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corrosion. Galvanic corrosion does not occur when aluminum is in contact with galvanized or stainless steel.

CHEMICAL CORROSION refers to the corrosion which takes place when aluminum comes in contact with concrete. When this happens a chemical reaction takes place between the aluminum and lime in the concrete which leads to progressive corrosion of the aluminum and loss of section. An inert spacer or bitumastic coating should be used between the concrete and aluminum to prevent chemical corrosion.

Figure 2.5.7.1 shows typical corrosion in aluminum.



Figure 2.5.7.1 Light Corrosion

2.5.7.2 Cracking

A crack is a linear fracture in the aluminum which may extend partially or completely through the material. Cracks normally develop as a result of fatigue followed by brittle fracture and excessive corrosion. Cracks may also be produced by freezing of entrapped water. Cracks initiate from either the inside or the outside surface of a member and become visible as hairline cracks on the surface. As cracks may be concealed by corrosion by-products, dirt or debris, the suspect surfaces should be cleaned prior to inspection. A crack in an aluminum component is illustrated in Figure 2.5.7.2.

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Figure 2.5.7.2 Cracks on an Aluminium Railing

2.5.7.3 Connection Deficiencies

Loose connections can occur in bolted, riveted or clamped connections. The loose condition may be caused by corrosion of the gusset plates or fasteners, cracking or failure of the individual fasteners, excessive vibration, over stressing, or simply a lack of proper tightening during construction.

Loose connections may not always be detectable by visual or hands-on inspection, as the looseness may only appear during serviceability loading. Cracking or excessive corrosion of the connector, gusset plates fasteners, as well as permanent deformation of the connection or members framing into it, may be indications of loose connections. Also, fasteners with missing washers or improper thread engagement are more susceptible to becoming loose over time, and should be inspected more closely. Tapping the connection with a hammer is one method of determining if the connection is loose.

Figure 2.5.7.3 shows an example of a missing bolt on hand railings.

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Figure 2.5.7.3 Missing Bolt on Aluminium Hand Railing

The other deficiencies typically associated with connections are corroded or cracked gusset plates.

The severity of the connection deficiency shall be based on the condition of the worst component within the connection. This means that the connection will be rated based on the looseness or corrosion of the worst component. In the case of truss members, the connection shall be taken as the entire joint or node location, including both gusset plates in and out of plane, with all members that frame in. Each connecting member and the gusset plates shall be inspected with the overall connection rating based on the worst of these components.

The location of the loose or missing fasteners, as well as areas of corrosion on gusset plates, should be described.

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2.5.7.4 Defect Table**Table 2.5.7.1: Aluminium Defect Definitions**

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Corrosion	Deterioration of steel by chemical/electro-chemical reaction resulting from exposure to air, moisture, de-icing salts, industrial fumes and other chemicals/contaminants in the environment in which it is placed		
	No section loss, loose rust/pitting in paint -	< 10% section loss, small scales or flakes -	> 10% section loss, extensive rust/perforations *
Permanent Deformations	Aluminum members can be subjected to bending, buckling, twisting or elongation deformations		
			For members: ALL (Estimate repair area) *
Cracking	Are linear fracture in the steel extending partially or completely through the member. They are mainly caused by fatigue, which can lead to brittle fracture (member cracks completely) through without prior warning		
	<i>Cracks perpendicular to stress are very serious and should have immediate action taken.</i>		ALL * (Estimate repair area)
Connection Deficiencies	Loose connections can occur in bolted, riveted or clamped connections. They may be caused by corrosion of the connector, gusset plates or fasteners, excessive vibration, overstressing, cracking, or the lack of proper tightening during construction.		
	Based on the condition of the worst component within the connection		
	Depends on percentage of Loose Bolts or Plan Area with severe corrosion		
	< 5% loose bolts or severe rust	< 10% loose bolts or severe rust or cracks	> 10% loose bolts or severe rust or cracks

2.5.8 Asphalt Wearing Surfaces

This section describes asphalt wearing surface material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.8.), then followed by photos to visually show sample defects.

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Asphalt pavement is often used as a wearing surface on concrete, steel and wood decks. The asphalt surface provides improved safety and riding qualities when compared with a concrete surface, reduces noise, and the asphalt also offers some protection to the concrete from traffic wear, and the weather. A waterproofing membrane is also often placed on the deck surface between the deck top surface and the asphalt pavement to provide protection to the deck surface against the infiltration of moisture and de-icing chemicals, and the subsequent deterioration or decay.

Wearing Course – Is a dense, highly stable, durable, skid-resistant surface course hot mix asphalt which carries traffic. It must resist the elements and keep water out of the underlying base material.

Binder Course – The binder course is the lower layer(s) of an asphalt pavement. It is normally distinguished from the surface course when there is a distinct difference in the quality of the mixtures used. It adds much to the overall strength of the pavement structure. It supports the surface course and distributes load to the base.

Flexible Pavement – A bituminous surface on a granular base (such as on the approaches of bridges without approach slabs).

Rigid Pavement – Including composite pavements consist of a concrete slab with bituminous overlays (such as on a bridge deck or approach slab).

Defects in asphalt pavements can be related to the lack of durability of the asphalt resulting from the composition of the asphalt, poor placement practices, lack of sub-grade support, reflection cracking, or the aggressive environment in which it is placed (Reference 4).

Asphalt Defects

Asphalt defects on concrete decks or slabs are sometimes an indication of deterioration of the concrete surface. For the purposes of bridge inspection, asphalt defects can be grouped into the following two general categories:

1) **Top-Down Defects**

Defects that originate in the asphalt itself, which do not have an appreciable effect on the concrete deck surface below. These include:

- i. Bond Defects (loss of bond and rippling)
- ii. Surface Defects (ravelling, slippery surface, and flushing)
- iii. Surface Distortions (wheel track rutting)
- iv. Isolated cracks (Light and medium isolated cracks)

2) **Bottom-up Defects**

Defects that probably originate in the concrete deck and are reflected in the asphalt surface. These include:

- i. Pattern cracking (map, alligator, radial, edge cracking)
- ii. Wide isolated cracks (transverse, longitudinal)
- iii. Local Underlying Defects (local potholes and protrusions)

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2.5.8.1 Cracking

A crack is a linear fracture extending partially or completely through the pavement. Cracking in pavements may be caused by any one or a combination of the following factors: the action of vehicular wheel loading; poor quality material; poor compaction; placement or quality control; frost action; poor drainage; shrinkage due to low temperatures; temperature susceptibility of the asphalt cement binder; and as reflection cracks, which are the extension of cracks in the surface below the pavement.

Cracks are distinguished by their appearance and direction. The following types of cracks are commonly observed in pavements; longitudinal, transverse, alligator, radial, map, and progressive edge cracking.

LONGITUDINAL cracks are roughly parallel to the direction of travel and may be situated at or near the centre of the wheel tracks, centreline of the roadway, middle of the lane, or along the pavement edges.

TRANSVERSE cracks are approximately at right angles to the pavement centreline and may extend partially or completely across the pavement.

ALLIGATOR cracks form a network of multi-sided polygons or blocks resembling the skin of an alligator. The block sizes typically range from 50 mm to 500 mm. They may occur anywhere in the pavement surface and may be accompanied by depressions in the surface.

RADIAL cracks in a radial pattern, usually about a depression.

MAP cracks run randomly along the pavement, sometimes in a serpentine manner. They appear to consist of longitudinal and transverse cracks combined to form a 'map' pattern.

PROGRESSIVE EDGE cracks begin parallel to and usually within 300 mm of the edges of the pavement; such as, along curb edges and expansion joint end dams. The cracks are either fairly straight and continuous or consist of crescent-shaped cracks in a wave formation. These cracks may progress significantly into the travelled portion of the pavement. Edge breaking of the pavement often results from these cracks.

The various types of pavement cracks are illustrated in Figure 2.5.8.1 to Figure 2.5.8.5.

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Figure 2.5.8.1 Wide Transverse and Longitudinal Cracks

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Figure 2.5.8.2 Medium Transverse Crack

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Figure 2.5.8.3 Severe Alligator Cracking



Figure 2.5.8.4 Map Cracking

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.8.5 Edge Cracking from Catch Basin

2.5.8.2 Bond Defects

Loss of Bond

Widespread loss of bond and delamination may occur between the asphalt pavement and deck surface, between the waterproofing and the deck surface, between the waterproofing and asphalt pavement or between individual lifts of pavement.

Loss of bond and delamination is not directly visible on the pavement surface; however, they may often be detected by hammer sounding or chain drag. The accurate assessment of the extent or severity of these defects can usually only be determined by detailed deck survey methods, such as thermography, radar and removal of the pavement.

PART 2 – DETAILED VISUAL INSPECTION

Rippling

Rippling is the formation of transverse undulations in the pavement surface consisting of closely spaced valleys and crests. Rippling is the result of poor bond of the pavement to the surface below with the subsequent action of wheel friction and braking forces moving the pavement 'mat' forwards, backwards and sideways.

Rippling of an asphalt pavement is illustrated in Figure 2.5.8.6.



Figure 2.5.8.6 Severe Rippling

2.5.8.3 Local Underlying Defects**Potholes**

Potholes are bowl-shaped holes in the pavement caused by the penetration of water through the pavement and the subsequent heaving of the pavement due to freezing of the entrapped water and breaking up of the pavement due to traffic action. They may result from delaminations or other defects in the underlying concrete surface. Potholes are bowl-shaped holes in the pavement caused by the penetration of water through the pavement and the subsequent heaving of the pavement due to freezing of the entrapped water and breaking up of the pavement due to traffic action. They may result from delaminations or other defects in the underlying concrete surface. Pavements already deteriorated with such defects as alligator cracking and raveling are prone to the occurrence of potholes.

PART 2 – DETAILED VISUAL INSPECTION

A typical example of a pothole is illustrated in Figure 2.5.8.7.



Figure 2.5.8.7 Severe Pothole

Local Protrusions (Delaminations)

Local delaminations become visible as protrusions or bumps. These are localized upward displacements of the pavement surface (often circular in shape) typically caused by frost action either between or under the layers of asphalt. They are generally the initial indications of the formation of potholes.

2.5.8.4 Surface Defects

Ravelling / Segregation

Ravelling is the progressive deterioration and loss of the pavement material from the surface downward. Ravelling begins on the surface but progresses down into the asphalt. The surface appears to be breaking up into small pieces and exposing and eventually loosening the aggregates. Ravelling can occur anywhere over the surface but is most common along curb or sidewalk faces where salt-laden roadway drainage collects, and along wheel tracks due to traffic action on pavements embrittled and weakened through aging. Severe ravelling may occur together with signs of cracking or potholes.

Ravelling of an asphalt pavement is illustrated in Figure 2.5.8.8.