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Figure 2.5.8.8 Light Ravelling

Flushing

Flushing is the migration of asphalt cement upwards to the pavement surface in pavements with too much asphalt cement in the pavement. It commonly occurs in the wheel tracks, especially during hot weather, by the action of vehicle traffic pressing and squeezing the excess asphalt to the surface. Flushing of the surface of an asphalt pavement is illustrated in Figure 2.5.8.9.

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Figure 2.5.8.9 Severe Flushing

Slippery Asphalt Surface

Slippery asphalt surfaces may result from flushing or from the polishing of the coarse surface aggregates by the action of repetitive vehicular traffic.

There are no severity descriptions given for slippery surfaces as this is a serious and potentially hazardous situation. Where evidence of slippery surfaces is noted, a suspected performance deficiency should be recorded, and the District and Regional Traffic Office shall be notified.

2.5.8.5 Surface Distortions

Wheel Track Rutting

Wheel track rutting is the formation of longitudinal depressions in the pavement at the locations of the wheel tracks of vehicles resulting from the compaction and shoving of the pavement laterally under repeated vehicle traffic.

Wheel track rutting is illustrated in Figure 2.5.8.10.

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Figure 2.5.8.10 Severe Wheel Track Rutting

2.5.8.6 Defect Table

Table 2.5.8.1 Asphalt Wearing Surface Material Defect Definitions

DEFECT		CONDITION STATE[1]		
		GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Crack	Pattern[2] (e.g., Map, alligator, radial, edge) and isolated[3]	Linear fracture extending partially or completely through the pavement		
		1—5 mm wide	6—10 mm wide	> 10 mm wide
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 the asphalt pavement or between individual lifts of pavement		
		< 150 mm in diameter	150—300 mm in diameter	> 300 mm in diameter
	Rippling	The formation of transverse undulations in the pavement surface consisting of closely spaced valleys and crests		
		A few noticeable bumps	Several bumps producing a rough ride	Numerous bumps producing a very rough ride and difficulty maintaining control of vehicle

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Surface Defects	Ravelling	Progressive deterioration and loss of the pavement material from surface downward		
		Noticeable loss of pavement material	Shallow disintegration of pavement with an open texture appearance	Shallow to deep disintegration of pavement with small/numerous potholes, open texture and loose surface material
	Slippery Surface	May result from flushing or from the polishing of the coarse surface aggregates by the action of repetitive vehicular traffic		
		There are no severity descriptions given for slippery surfaces as this is a serious and potentially hazardous situation resulting in loss of riding comfort and loss of vehicle control (indicate suspected perform deficiency of slippery surface)		
	Flushing	The migration of asphalt upwards to the pavement surface in pavements with too much asphalt in the mix.		
		Visible colouring of the pavement surface occurring in localized areas	Distinctive colouring of the pavement surface with excess asphalt free on the pavement surface	Excessive free asphalt gives the pavement surface a “wet look”. Visible imprints left from footprints or vehicular traffic
Surface Distortion	Wheel track rutting	The formation of longitudinal depressions in the pavement at the locations of the wheel tracks of vehicles		
		Rutting < 10 mm deep	Rutting 10 to 20 mm deep	Rutting > 20 mm deep
Underlying Local Defects	Potholes	Bowl-shaped holes in the pavement caused by the penetration of water through the pavement and subsequent heaving of the pavement due to freezing of the entrapped water and breaking up of the pavement due to traffic action		
		< 10 mm deep	10 to 20 mm deep	> 20 mm deep
	Protrusions (Delaminations)	Local delamination is visible as protrusions or bumps (often circular in shape)		
		< 10 mm in height	10 to 20 mm in height	> 20 mm in height

Notes:

1) Excellent Condition – No observed material defects.
2) For all calculations, the actual area shall be determined for areas containing numerous cracks (i.e., alligator cracks, radial cracks).
3) For isolated cracks, 4 m of crack length is equal to 1 square meter of defect repair area.

2.5.9 Bearings

Bearing material defect definition table for each condition state:

Defects	Good Condition	Fair Condition	Poor Condition
Cracks in elastomeric pads	Hairline, less than 0.1 mm wide	Narrow to medium, 0.1 mm to 1.0 mm wide	Wide cracks, greater than 1.0 mm wide, and/or steel plates debonded
Bulging or shear deformations in elastomeric pads	Light	Medium	Severe
Local deformation of roller/rocker plates	Light	Medium	Severe
Scoring/scratches in TFE or stainless steel	Light	Medium	Severe and/or rips and tears
Corrosion	Light	Medium	Severe and very severe and/or cracks in steel
Anchor bolts	slightly bent	significantly bent	Cracked or broken
Guide bars and thrust plates	slightly worn	moderately worn	severely worn and/or loose or missing nuts
Bonded sliding surface is debonded	Up to 5%	5% to 20%	Over 20%
			Internally confined compression material is squeezing or squeezed out

Note: *Excellent Condition – No observed material defects.*

2.5.10 Expansion Joint – Armouring And Retaining Devices

Expansion joint armouring defect definition table for each condition state:

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	< 10% section loss, small scales or flakes -	> 10% section loss, extensive rust/perforations

Note: *Excellent Condition – No observed material defects.*

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2.5.11 Expansion Joint – Seals / Sealants

Expansion joint seal/sealant defect definition table for each condition state:

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Defect in seal	Abrasions with no perforations	Loss of resiliency with no perforations	Cracks, tears or holes
			Debonded or allowing leakage on the substructure
Defect in sealant			Debonded, pulled out or settled.

Note: *Excellent Condition – No observed material defects.*

2.5.12 Drainage System

Drainage system defect definition table for each condition state:

Defects	Good Condition	Fair Condition	Poor Condition
Individual drainage system has loose or deteriorated components, connections or fasteners	Up to 20%	20% to 60%	More than 60%
			Broken pipe components resulting in water draining onto substructure

Note: Excellent Condition – No observed material defects.

2.5.13 Soil-Steel Structures

Soil-steel structure defect definition table for each condition state:

Defects	Good Condition	Fair Condition	Poor Condition
Cusping or crimping of corrugations		Medium (less than 10 mm in height)	Severe (greater than 10 mm in height)

Global Deformation		Medium (less than 10% of culvert diameter)	Severe (greater than 10% of culvert diameter or with reverse curvature)
Corrosion	Light (surface rust)	Medium	Severe
pitting		shallow	deep
Corrosion scale over surface		less than 10% section loss)	greater than 10% section loss)
Bolt tilting		✓	
Cracks			✓

Notes:
1) Excellent Condition – No observed material defects.
2) Unit of measurement for soil-steel structures is m^2.
3) The area of defect should be recorded for Severe Corrosion (excluding corrosion with perforations), as well as for the Excellent, Good, and Fair Condition States.
4) For all other portions in the Poor Condition State (cusping, crimping, deformations, cracks, and corrosion with perforations), the area shall be taken to include the entire circumference. This is due to the importance of soil-steel interaction and continuity of the radial corrugations of steel where such a defect at one point on the culvert will affect the entire circumference.

2.5.14 Masonry

This section describes masonry material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.14.), then followed by photos to visually show sample defects.

Masonry is made of stones or bricks bonded together by mortar. Although not a common construction material today, masonry was used in Ontario, usually in retaining walls, abutments, piers or arches, primarily in the 19th century while brick masonry was only rarely used in highway structures. Types of masonry construction are ashlar masonry, squared stone masonry and rubble masonry.

The following defects commonly occurring in masonry are described:

- Cracking.
- Splitting, Spalling and Disintegration.
- Loss of Mortar and Stone.

2.5.14.1 Cracking

A crack is an incomplete separation into one or more parts with or without space in between. Cracks develop in masonry because of non-uniform settlement of the structure, thermal restraint, frost action and overloads.

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Cracks develop either at the interface between the stone and mortar, following a zig-zag pattern, when the bond between them is weak; or, go through the joint and stone, in a straight line, when the mortar is stronger than the stone, as shown in Figure 2.5.14.1.

Figure 2.5.14.1 Wide Crack Through the Stone in a Masonry Pier

2.5.14.2 Splitting, Spalling and Disintegration

SPLITTING is the opening of seams or cracks in the stone leading to the breaking of the stone into large fragments.

SPALLING is the breaking or chipping away of pieces of the stone from a larger stone.

DISINTEGRATION is the gradual breakdown of the stone into small fragments, pieces or particles. The splitting, spalling and disintegration of masonry is caused by the actions of frost, weathering and abrasion; or, by the actions of acids, sulphates or chlorides, which cause deterioration in certain types of stones, such as limestone. The splitting, spalling and disintegration of masonry are shown in Figure 2.5.14.2.

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Figure 2.5.14.2 Severe Splitting, Spalling, and Deterioration in Masonry

2.5.14.3 Loss of Mortar and Stones

Loss of mortar is the result of the destructive actions of frost, erosion, plant growth or softening by water containing dissolved sulphates or chlorides. Once the mortar has disintegrated it may lead to loss of stones. It should be noted that some structures have been built without the use of mortar. Figure 2.5.14.3 shows evidence of loss of mortar in a masonry arch.

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Figure 2.5.14.3 Severe Loss of Mortar and Stone in a Masonry Arch

2.5.14.4 Defect Table

Table 2.5.14.1 Masonry Defect Definitions

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Cracking	Incomplete separation into one or more parts with or without space between		
	< 0.3 mm wide	0.3 to 1.0 mm wide	> 1.0 mm wide
Splitting	The opening of seams or cracks in the stone leading to the breaking of the stone into large fragments		
Spalling	The breaking or chipping away of pieces of the stone from a larger stone		
Disintegration	Gradual breakdown of the stone into small fragments, pieces or particles		
Splitting, Spalling	Hairline cracking and minor loss of stone	Narrow cracking or chipping away of stone	Extensive spalling and disintegration of stone with

Disintegration	surface with section loss < 50 mm	with section loss 50 to 100 mm	section loss > 100 mm
Loss of Mortar or Stone	Result of the destructive actions of frost, erosion, plant growth or softening by water containing dissolved sulphates or chlorides.		
	Mortar lost from joints in a few places to a depth of 20 mm	Mortar lost from joints over an extended area to a depth of 20 to 50 mm	Extensive mortar/stone loss endangering the stability of the structure

2.5.15 Wood

This section describes wood material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.15.), then followed by photos to visually show sample defects.

Wood was one of the earliest materials used for structures, and is still in common use today. This is largely due to its availability in a variety of structural sizes and ease of handling.

The following defects commonly occurring in wood are described:

- Checks, Splits and Shakes;
- Weathering;
- Rot or Decay;
- Insect Damage;
- Abrasion and Wear;
- Cracking, Splintering, Crushing and Shattering;
- Fire and Chemical Damage;
- Connection Deficiencies.

2.5.15.1 Checks, Splits and Shakes

Checks are longitudinal tissue separations on the side grain of wood members, occurring across or through the annual growth rings.

Splits are similar to checks, with more severe tissue separations, extending either through the wood member or from the side into the end grain, typically at the ends of the wood member.

Shakes are tissue separations which follow the circular annual growth rings and are usually visible on the end grain.

Checks, splits and shakes are illustrated in Figure 2.5.15.1 with examples from Figure 2.5.15.2 to Figure 2.5.15.4.

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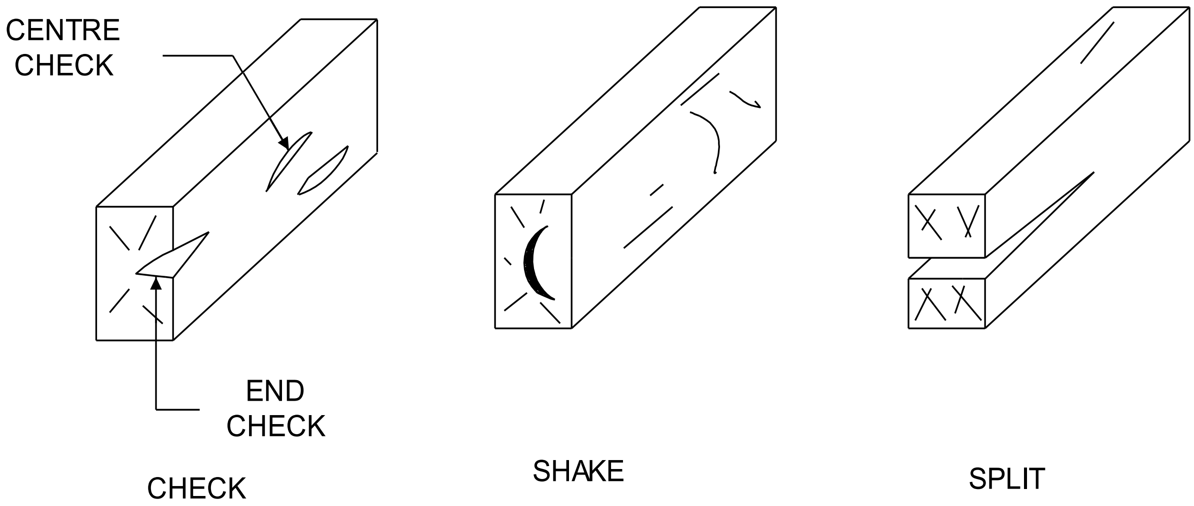

Figure 2.5.15.1 Checks, Shakes, and Splits in Wood

Figure 2.5.15.2 End Check in Wood Beam

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Figure 2.5.15.3 Severe Shakes in Wood Components

Figure 2.5.15.4 Severe Split in Wood Bracing

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2.5.15.2 Weathering

Weathering is the gradual deterioration of wood due to exposure to the actions of sun, rain, wind, frost and atmospheric pollutants. Weathering of untreated wood is accompanied by softening of the surface layer and a grey discolouration and "barn-board" appearance. Treated wood weathers more slowly to a gray-brown colour and may exhibit a rough "wash-board" appearance. Light weathering is shown in Figure 2.5.15.5.

Figure 2.5.15.5 Light Weathering with Medium Checks in Wood Components

2.5.15.3 Rot or Decay

Rot or decay is the biological decomposition of wood caused by micro-organisms called fungi. Rot develops in progressive stages, usually through cracks, knots, holes and at the ends of members. The growth of fungi requires the presence of adequate moisture, a supply of oxygen and a favourable (warm) temperature. The absence of any of these factors will greatly inhibit or prevent fungal growth. The most common method of reducing rot or decay in wood is by pressure treatment with preservatives.

- The following areas are typically prone to decay:
- Wood in contact with soil;
- Wood at the water line;

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- Surfaces in contact where water can be trapped, such as, connections and bearing areas;
- At checks, splits, shakes and cracks, through which moisture can penetrate the wood.
- At the centre core of wood, especially for piles;

Three types of rot may be identified in wood; namely, white rot, brown rot and soft rot.

White rotted wood has a bleached appearance, and in advanced stages the wood appears as a grey fibrous mass. It develops at or above ground contact and may attack both the surface and interior portions of wood.

Brown rotted wood has a reddish-brown appearance, and in advanced stages the wood has a checked or crumbly surface. It develops at or above ground contact and may attack both the surface and interior portions of wood.

Soft rotted wood has a soft, spongy surface, and in advanced stages the wood has a charred appearance. It usually develops below ground level or under water, and usually attacks only the surface of the wood.

The surface appearance of rotted wood is shown in Figure 2.5.15.6.

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Figure 2.5.15.6 Severe Brown Rot

2.5.15.4 Insect Damage

Defects in wood caused by insects are a consequence of the tunnelling and boring by larvae or mature insects through the wood resulting in loss of section. Termites, carpenter ants and wood-boring beetles are the most common insects that attack wood in Ontario. Their appearance is shown in Figure 2.5.15.7, and the resulting appearance of insect damaged wood is shown in Figure 2.5.15.8.

The severity of the insect damage can be judged by the number of holes and tunnels on the surface of the wood and by the number of insects around the area.

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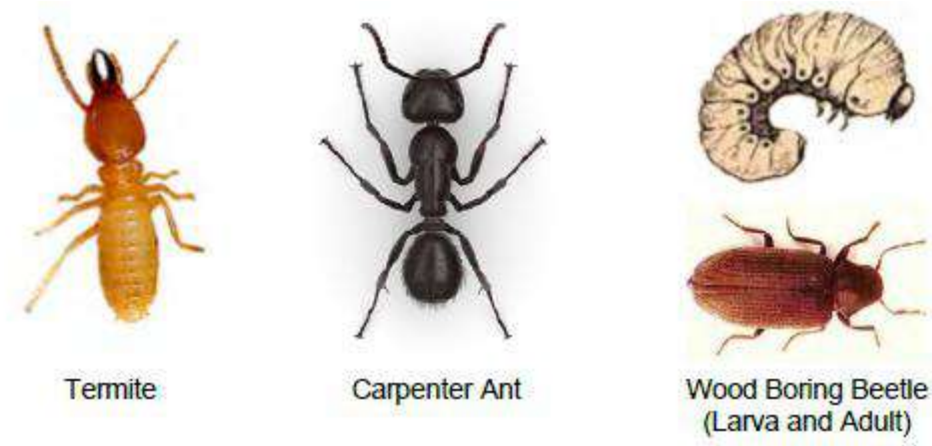

Figure 2.5.15.7 Wood-Boring Insects

Figure 2.5.15.8 Severe Insect Damage in Wood

2.5.15.5 Abrasion and Wear

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Abrasion is the deterioration of wood brought about by vehicles or snowplough blades scraping against wood surfaces, such as, decks, curbs, railings or piers.

Wear is usually the result of dynamic and/or frictional forces generated by vehicular traffic, coupled with the abrasive influence of sand, dirt or debris. It can also result from the friction of ice or water-borne particles against partly or completely submerged members. The surface of the wood appears worn and cracked with some loss of section. Wear of a wood deck an by ice and abrasion on wood crib are illustrated in Figure 2.5.15.9 and Figure 2.5.15.10 respectively.

Figure 2.5.15.9 Severe Wear in a Wood Deck

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Figure 2.5.15.10 Severe Abrasion and Medium Checking on Wood Crib

2.5.15.6 Cracking, Splintering, Crushing and Shattering

Cracking, splintering, crushing and shattering are forms of physical damage which result from vehicular collision or from overloading of a member. Particularly susceptible are members already weakened by rot or insect attack.

A crack is an incomplete separation of the wood into two or more parts with or without space in between. Cracking across the grain is caused by flexural damage through overloading. Cracking along the grain may be due to shear failure or a continuation of a split.

Splintering is a series of localized tensile failures in the wood where fragmented parts of the wood may protrude from the surface.

Crushing is a form of permanent deformation where a portion of the wood has lost its resiliency to rebound. Crushing at the bearings occurs due to excessive compression. Crushing may also occur prior to a flexural failure.

Shattering is a combined form of crushing and splintering resulting from impact.

Crushing and splintering of wood pier is shown in Figure 2.5.15.11.

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Figure 2.5.15.11 Severe Splitting of Wood Pier

2.5.15.7 Fire and Chemical Damage

Fire damage is evidenced by charring and is usually confined to the wood surface. Connectors may sustain more damage from fire than the members connected. Such damage to connections is manifested by large deformations of the connector plates and fasteners, and by loose or misaligned joints.

Chemical damage may result from the use of non-preservative chemicals on the wood surface over a long period of time, or where the wood comes in contact with corrosive chemicals resulting from accidental spills. Such damage affects the wood surface and metal connectors. The effect of chemicals on the wood is a softening of the surface accompanied by loss of strength. The effect on metal connector plates and fasteners is less critical except in certain circumstances, for example, on fasteners with low corrosion resistance.

Figure 2.5.15.12 and Figure 2.5.15.13 shows fire and chemical damaged wood.

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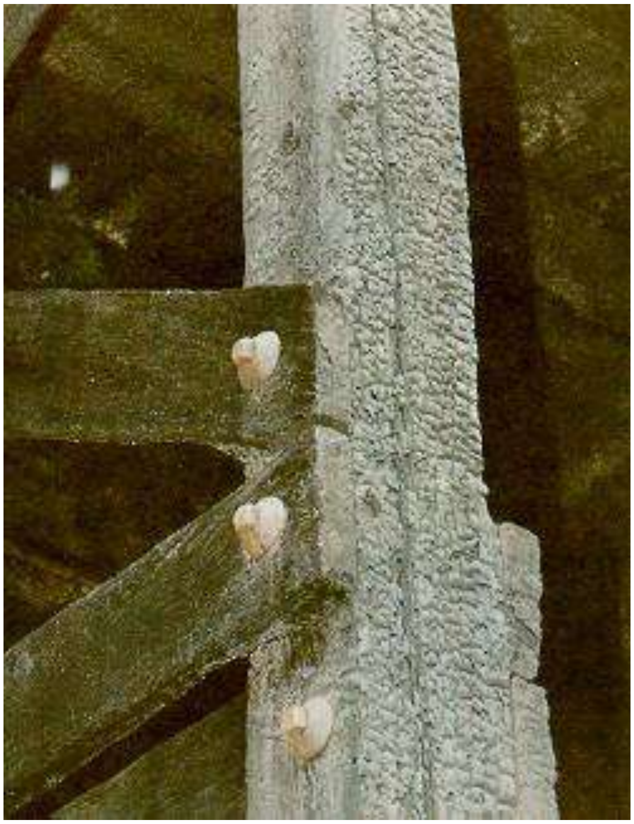

Figure 2.5.15.12 Medium Fire Damage on Wood

Figure 2.5.15.13 Light Chemical Damage on Underside of a Wood Deck

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2.5.15.8 Connection Deficiencies

Wood members are normally connected with common nails, spikes, bolts, shear plates, split rings, metal framing connectors or glulam rivets. Most connections are loosened due to repetitive or dynamic loads, wear or decay of members connected, and corrosion of the connectors.

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 plates or fasteners, as well as permanent deformation of the connection or members framing into it, may be indications of loose connections.

A loose connection joining wood members is shown in Figure 2.5.15.14.

Figure 2.5.15.14 Loose Connection in Wood (25 mm gap measured)

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, decay 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 into the connection.

The location of the loose or missing fasteners, as well as areas of corrosion any gusset plates, should be described. Any unintended gaps that are observed should be measured and recorded.

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2.5.15.9 Defect Table

Table 2.5.15.1 Wood Defect Definitions

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Weathering	Gradual deterioration of wood due to exposure to the actions of sun, rain, wind, frost and atmospheric pollutants		
Checks[2]	Longitudinal tissue separations on the side grain of wood members		
Splits	Severe tissue separations extending from the side into the end		
Shakes[2]	Tissue separations which follow the circular annual growth rings, and are visible on the end grain		
Weathering	< 5% into member	5—10% into member	> 10% into member
Checks, Splits, Shakes	< 5% into member	5—10% into member	> 10% into member
Rot or Decay	Biological decomposition of wood caused by micro-organisms called fungi		
	Slight change in colour but wood solid (< 5% loss)	Surface is discoloured and slight hollow sound (5% - 10% loss)	Surface is fibrous or crumbly and hollow sounding or surface and interior is crumbly and wood is weak (> 10 % loss)
Insect Damage	Consequence of the tunnelling/boring by larvae/mature insects through the wood resulting in loss of section		
	Holes are present (< 5% loss)	Holes and insects present (5% - 10% loss)	Extensive/severe holes and insects (> 10% loss)
Abrasion and Wear	Deterioration of wood brought about by vehicles or snowplough blades scraping against wood surfaces, coupled with the abrasive influence of sand, dirt or debris.		
	< 5% loss	5% - 10% loss	> 10% loss
Cracking, Splintering, Crushing and Shattering	Physical damage which results from vehicular collision from overloading of a member		
	< 5% loss	5% - 10% loss	> 10% loss
Fire and Chemical Damage	Fire is evidenced by charring and is usually confined to the wood surface. Chemical damage may result from the use of non preservative chemicals on the wood surface over a long period of time		
	Slight charring or softening with < 5% section loss	Deeper charring or softening with slight loose connectors with 5% - 10% section loss	Extensive damage with loose and severely deformed connectors > 10% section loss

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Connection Deficiencies	Connections are loosened due to repetitive or dynamic loads, wear or decay of members connected and corrosion of the connectors		
	< 5% loose bolts or severe rust	< 10% loose bolts or severe rust	> 10% loose bolts or severe rust

Notes:
1) Excellent Condition – No observed material defects.
2) These naturally occurring cracks in the wood, caused by shrinkage, are not as severe as overload cracking or splintering since wood fibres exist to bridge the crack and reduce the impact on the member capacity. The actual area containing the defect shall be determined for areas containing numerous defects. For isolated cracks, 8 m of crack length is equal to 1 square metre of defect for checks, shakes and splits; while 4 m of crack length is equal to 1 square metre of defect for cracking, splintering, crushing and shattering. The length of cracks, shakes, splits, etc. shall be measured on all surfaces.

2.5.16 FRP Composite Materials

This section describes FRP composite material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.16.).

Fibre reinforced polymer (FRP) materials are increasingly being applied for the rehabilitation and strengthening of reinforced concrete structures.

Most defects in FRP composites arise from impact, abrasion, or ultra-violet exposure.

While non-metallic connectors exist, traditional metallic connectors are widely used. These connectors may not match the service life of the FRP and, in some cases, may be stronger than the FRP itself, leading to yielding or splitting of the composite material.

FRP can degrade from fire and ultraviolet exposure, though coatings and admixtures can mitigate these effects. Common FRP deficiencies include:

- Delamination / Debonding
- Discoloration
- Wrinkling / Blistering
- Fiber exposure
- Cracking

Acoustic Sounding

The coin tapping technique is a conventional acoustic testing method used to locate subsurface defects (delamination or voids) in thin FRP wraps.

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2.5.16.1 Defect Table

Table 2.5.16.1 - FRP Defect Definitions

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Delamination / Debonding	Discontinuity or loss of adhesion between the FRP and the concrete to steel substrate it is bonded to. Indicated by “hollow” sounds during tap testing.		
	No delam or debonding or wrinkling	< 10% debonded	> 10% debonded
Fibre Exposure	Indicates degradation of the protective epoxy resin.		
	No peeling or fibre rupture	< 10% fiber rupture or edge peeling	> 10% tearing or rupture of the fibers, severe corrosion of the underlying concrete (if the wrap has failed to prevent water/chloride intrusion), or significant peeling of the wrap
Environmental Degradation	Discoloration or UV damage to the matrix.		
	Surface resin is intact with no discoloration, cracking blistering.	Light discolouration	Widespread blistering, resin loss, discolouration
Cracking	Linear separation or fracture that occurs in the FRP system’s resin matrix, fibers, or both.		
	Very fine, cosmetic surface cracks limited to the resin/gel coat. No fracture of fibers.	Cracks extend through the resin and expose fibers. Cracks extend through the resin and expose fibers	Cracks may propagate along the principal fiber direction. Structural performance of the FRP system is substantially compromised.

2.5.17 Embankments

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Embankments are sloped fills or cuts in the vicinity of the structure. The purpose of the embankments is to provide for a stable change of grade between the roadway and the surrounding ground surface, streams or other roadways under the structure. Another purpose of the embankments is to provide support for the foundations where they are situated within the embankments.

Embankments are normally constructed from earth, rock or a combination of these materials. The sloping faces of embankments may be protected from the effects of erosion or scour by slope protection systems.

Embankments are to be considered as primary components if they support the foundation, otherwise, they are to be considered as secondary components.

2.5.17.1 Material Defects of Embankments

EROSION is the gradual wearing away or removal of material by surface drainage or wind. Sources of surface drainage potentially leading to erosion are leakage through expansion joints onto the embankment, runoff around the ends of wingwalls, discharge from deck drains directly above the embankment and abutment and wingwall subdrains discharging onto the embankment.

PIPING is the subsurface removal of fines by movement of water through the ground or embankment.

WASHOUT is the removal of material from the ground or embankment by subsurface or surface erosion.

SCOUR is the removal of embankment material by the action of stream flow.

2.5.17.2 Performance Defects of Embankments

Performance defects in embankments are related to their ability to maintain a stable grade separation between the roadway and the surrounding terrain without appreciable movement. Performance defects are also related to the ability of the embankments to provide support to the foundations without appreciable movements where the foundations are supported by the embankments.

Movement of embankments may consist of:

- settlement of embankment or roadway approaches;
- sliding of the slopes or toes of embankments;
- surface or deep seated slips.

Movement of embankments may result from:

- improper or inadequate compaction of fill;

- instability of the underlying soils;
- instability of the embankment material;
- loss of embankment material due to erosion, scour; piping, undermining,
- disintegration or other causes (e.g. burrows).

UNDERMINING is the progression of scour of the embankment or the stream bed under the embankment.

2.5.17.3 Defect Table

Table 2.5.17.1 Embankments Defect Definitions

Defects	Good Condition	Fair Condition	Poor Condition
loss of material for embankments not directly supporting foundations	Up to 10%	10% to 30%	More than 30%
loss for embankments directly supporting foundations	up to 5%	5% to 15%	More than 15%
loss of material to the top of foundations		5% to 15%	
loss of material to the bottom of foundations			More than 15%

Note: Excellent Condition – No observed material defects

2.5.18 Slope Protections

This section describes slope protection defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.18.2.5.6).

The purpose of the slope protections is to prevent the erosion or scour of embankments and stream banks in the vicinity of structures. A secondary purpose is to control the growth of grass and vegetation on steep slopes where mechanical equipment cannot be used safely.

The types of slope protection systems used most commonly are summarized in Table 2.5.18..

2.5.18.1 Material Defects of Slope Protections

- Loss of slope protection material.
- Disintegration or breakdown of material.
- Tearing of geotextiles.

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- Corroded or broken wire mesh.

2.5.18.2 Performance Defects of Slope Protections

Performance defects in slope protections are related to their ability to protect the embankments and stream banks from erosion or scour and are reflected in the movements of slope protection systems.

Movements of slope protections may consist of:

- settlement of the slope protection;
- sliding of the slope protection.

Movements of slope protections may be caused by:

- movements of the embankments or the stream banks;
- material defects of the slope protection systems.

2.5.18.3 Defect Tables

Table 2.5.18.1 Slope Protection Systems

Type		Material Composition	Remarks
1	Organic	Grass, Brush, etc.	Used where large run-off is not expected.
2	Rip-Rap	Stones, Rubble.	Random, hand-laid or grouted. Commonly used in streams.
3	Granular	Crushed stone or gravel.	Commonly used at grade separations
4	Cast-in-Place Concrete	Reinforced concrete slab, 100 mm to 150 mm thick, divided into panels.	Commonly used at grade separations
5	Precast Concrete	Interlocking slabs or elements.	Elements placed on permeable base which permits some seepage between elements
6	Bituminous	Asphaltic concrete	Compacted.
7	Wire Baskets	Wire mesh baskets filled with stones.	Commonly used near streams.