

PART 2 – DETAILED VISUAL INSPECTION

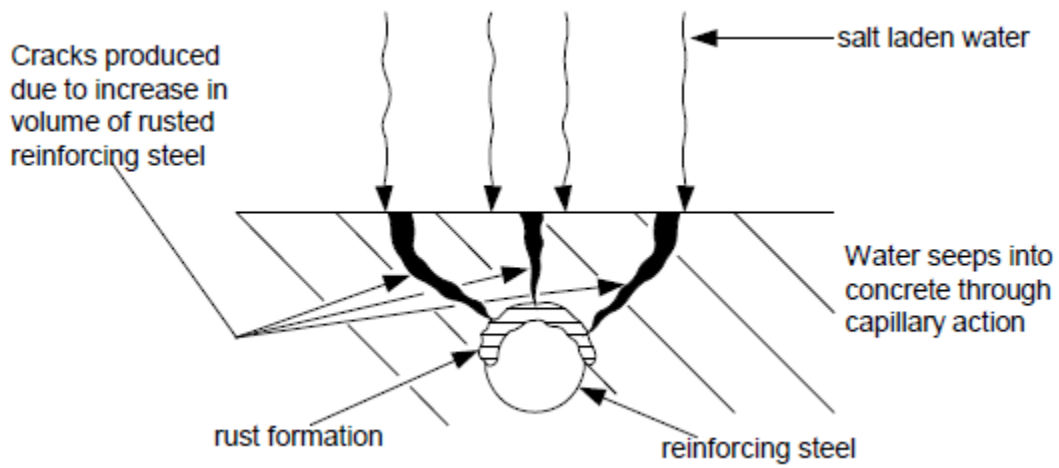


Figure 2.5.4.4 Process Leading to Corrosion of Reinforcement



Figure 2.5.4.5 Stains on Concrete Surface Indicating Corrosion of Reinforcement

PART 2 – DETAILED VISUAL INSPECTION

2.5.4.5 Delamination

Delamination is defined as a discontinuity of the surface concrete which is substantially separated but not completely detached from concrete below or above it. Visibly, it may appear as a solid surface but can be identified as a hollow sound by tapping or chain dragging. Delamination begins with the corrosion of reinforcement and subsequent cracking of the concrete. However, in the case of closely spaced bars, the cracking extends in the plane of the reinforcement parallel to the exterior surface of the concrete. Delaminations in concrete beams is shown in Figure 2.5.4.6.

Delamination or debonding may also occur in concrete that has been patched or overlaid due to the continued deterioration of the older concrete. This may happen even in the absence of any rusting of reinforcing steel.



Figure 2.5.4.6 Severe Spalling and Delamination in Concrete Beams

2.5.4.6 Spalling

A spall is a fragment, which has been detached from a larger concrete mass.

Spalling is a continuation of the delamination process whereby the actions of external loads, pressure exerted by the corrosion of reinforcement or by the formation of ice in the delaminated area results in the breaking off of the delaminated concrete. The spalled area left behind is

PART 2 – DETAILED VISUAL INSPECTION

characterized by sharp edges. Severe spalling in an abutment and local severe spalling in a concrete soffit are illustrated in Figure 2.5.4.7 and Figure 2.5.4.8 respectively.

Vehicular, ice flow or other impact forces on exposed concrete edges, deck joints or construction joints, may also result in the spalling or breaking off of pieces of concrete locally.

Spalling may also be caused by overloading of the concrete in compression. This results in the breaking off of the concrete cover to the depth of the outer layer of reinforcement. Spalling may also occur in areas of localized high compressive load concentrations, such as at structure supports, or at anchorage zones in post-tensioned concrete.

Spalling of patched areas may occur due to continued deterioration of the old concrete and subsequent breaking off of the new patch.



Figure 2.5.4.7 Severe Spalling in Concrete Due to Corrosion of Reinforcement

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.4.8 Severe Local Spalling

2.5.4.7 Cracking

A crack is a linear fracture in concrete which extends partly or completely through the member. Cracks in concrete occur as a result of tensile stresses introduced in the concrete. Tensile stresses are initially carried by the concrete and reinforcement until the level of the tensile stresses exceeds the tensile capacity (modulus of rupture) of the concrete. After this point the concrete cracks and the tensile force is transferred completely to the steel reinforcement. The crack widths and distribution are controlled by the reinforcement in reinforced and prestressed concrete, whereas in plain concrete there is no such control.

The build-up of tensile stresses and, therefore, cracks in concrete may be due to externally applied loads, external restraint forces, internal restraint forces, differential movements and settlements, or corrosion of reinforcement. Externally applied loads generate a system(s) of internal compressive and tensile stresses, in the members and components of the structure, as required to maintain static equilibrium. Cracks resulting from externally applied loads initially appear as hairline cracks and are harmless. However, as the reinforcement is further stressed the initial cracks open up and progressively spread into numerous wider cracks. Figure 2.5.4.9 shows typical flexure, shear, axial and torsional cracks due to applied external load.

PART 2 – DETAILED VISUAL INSPECTION

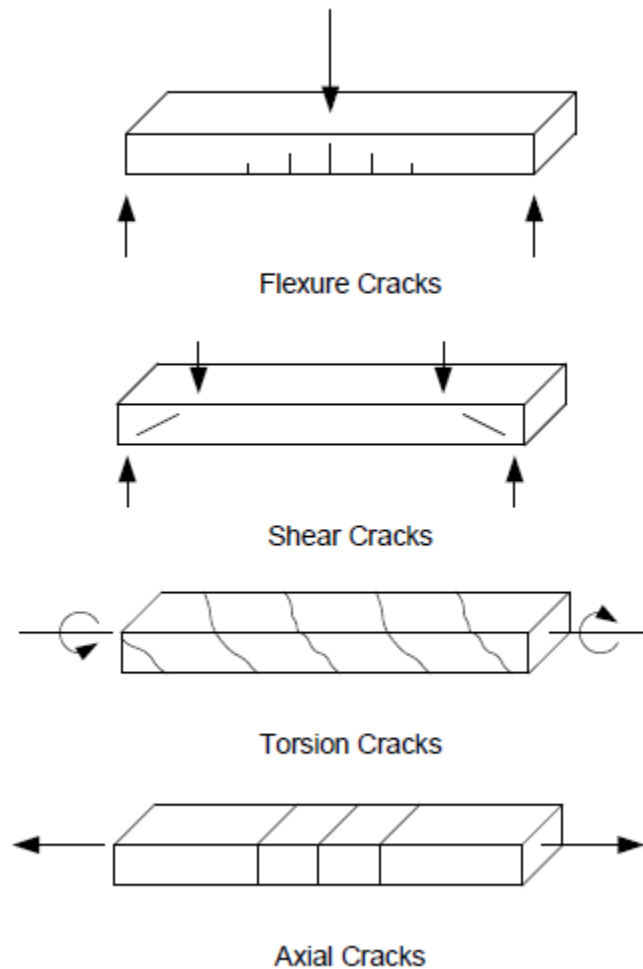


Figure 2.5.4.9 Applied Loading Cracks

External restraint forces are generated if the free movement of the concrete in response to the effects of temperature, creep and shrinkage is prevented from occurring due to restraint at the member supports. The restraint may consist of friction at the bearings, bonding to already hardened concrete, or by attachment to other components of the structure. Cracks resulting from the actions of external restraint forces develop in a similar manner as those due to externally applied loads. Figure 2.5.4.10 shows restraint induced cracking due to an increase in temperature of the top surface of a beam.

PART 2 – DETAILED VISUAL INSPECTION

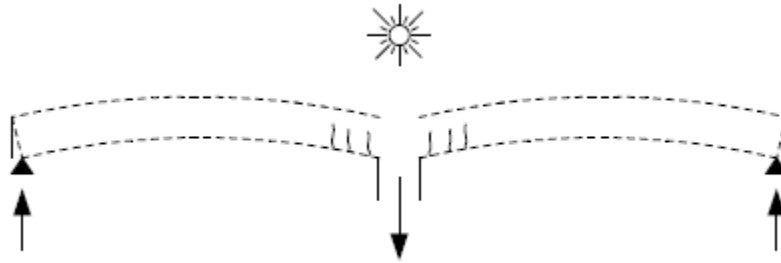


Figure 2.5.4.10 External Resistant Induced Cracks (due to temperature increase in top surface of beam)

Internal restraint forces are caused by the differential expansion or contraction of the exterior surface of concrete relative to the interior mass of the concrete, as in plastic shrinkage. The resulting surface cracks are normally shallow and appear as pattern cracks, checking and D-cracks. Figure 2.5.4.11 shows pattern cracking in an abutment wall.



Figure 2.5.4.11 Pattern Cracks in Abutment

These internal forces may also be caused by carbonation of concrete. The calcium from the concrete reacts with carbonic acid (which occurs when the carbon dioxide in the air combines with moisture) resulting in a volume decrease. This volume decrease occurs only in the outer layer of the concrete, but usually hairline pattern cracks and a surface discolouration result.

Differential movements or settlements result in the redistribution of external reactions and internal forces in the structure. This may in turn result in the introduction of additional tensile

PART 2 – DETAILED VISUAL INSPECTION

stresses and, therefore, cracking in the concrete components of the structure. Movement cracks may be of any orientation and width, ranging from fine cracks above the reinforcement due to formwork settlement, to wide cracks due to foundation or support settlement. Figure 2.5.4.12 shows a very wide movement or settlement crack in an abutment.



Figure 2.5.4.12 Very Wide Movement Crack in an Abutment

Corrosion of reinforcement produces cracks as described in Section 2.5.4.4. Corrosion related cracks are shown in Figure 2.5.4.13.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.4.13 Medium Crack due to Corrosion of Reinforcement

2.5.4.8 Alkali-Aggregate Reaction (AAR)

In Ontario, there exists several sources of aggregates that react adversely with the alkalis in cement to produce a highly expansive gel. Currently, these sources of reactive aggregates are generally avoided and not permitted to be used in concrete mixes. MTO has created an Aggregate Sources list that identifies acceptable aggregates, but unfortunately, they do exist in many existing structures built prior to the 1986's, but they still may occur in newer structures.

The two general types of reactions in Ontario are alkali-carbonate and alkali-silica reaction. The expansion of the gel and aggregates occurs due to hydroxyl ions in the concrete pore solution, which under moist conditions, leads to cracking and deterioration of the concrete. Normally, higher alkali content of the cement and higher cement content of the concrete will lead to a higher rate of expansion and cracking. The cracking occurs through the entire mass of the concrete (Reference 1). Alkali-aggregate reactions are generally slow by nature, especially at the start, and the results may not be apparent for many years. Once the alkali-aggregate reaction starts, there are no remedial measures to stop or reverse the process of deterioration; however, sealing the surface to reduce the moisture infiltration does slow down the reaction. The appearance of concrete affected by alkali-aggregate reactions is shown in Figure 2.5.4.14.

Alkali-silica reaction (ASR) has been documented to be widespread in Ontario prior to the adoption of pre-approved aggregate sources in 1986 however the severity of reaction ranges widely. In a 1969 review by the Ontario Department of Highways of 1200 bridges 80 were visually identified and subsequently cored and analyzed confirming the presence of ASR in nearly all samples. Only 4% were considered severely affected. Alkali-carbonate reaction (ACR) is highly expansive and destructive but has been found in very limited locations in Ontario. The occurrence of ACR has been attributed to dolomitic limestone sources from the Pittsburg Quarry near Kingston, quarries in the Gull River formation between Orillia and Kingston, and east of Ottawa. (Reference 1)

PART 2 – DETAILED VISUAL INSPECTION

In all cases, ASR is typically identified by randomly oriented map cracking in elements that are unrestrained in all direction. When restrained in one or more direction due to internal confinement or reinforcing, expansion occurs in the direction of least restraint. In the case of reinforced concrete columns, cracks tend to align vertically. (FHWA, 2011). In precast girders cracks typically align horizontally along the length of the girder.



Figure 2.5.4.14 Severe Alkali-Aggregate Reaction

2.5.4.9 Delayed Ettringite Formation (DEF)

Ettringite is a hydrated calcium aluminum sulfate mineral and is a rare natural mineral but is a common hydration product of Portland cement. The formation of ettringite is accompanied with expansion but, under normal curing temperatures this expansion does not harm the fresh concrete. Ettringite is stable only at temperatures less than 60°C. If concrete temperatures exceed this temperature at early stage during the first few days of the curing period, the ettringite becomes unstable and monosulfate will form instead. Once the concrete temperature drops down, the monosulfate will transform to ettringite (delayed ettringite formation “DEF”). The expansion caused by DEF causes the concrete to develop microcracks leading to cracks and further damage to the concrete.

The risk of DEF increases with the increase in curing temperature above 60°C. At 70°C, the risk of DEF could be significant. In general, national and international standards, guidelines and

PART 2 – DETAILED VISUAL INSPECTION

specifications set a 70°C limit to prevent DEF damage. The temperature exceedance could occur due to excessive heating of concrete during the curing period or due to accumulation of heat from cement hydration in mass concrete elements.

Elements that are particularly prone to this are large foundational elements.

Additionally, precast elements can be prone to this if curing temperatures are not controlled, which is particularly important for steam cured elements.

DEF is problematic because as the monosulfate converts to ettringite it migrates towards water and moist areas. Ettringite formation in the paste portion of the concrete will cause the concrete to expand and crack, which exposes the concrete to even more moisture which accelerates the process. Ettringite (“secondary ettringite”) will form in the entrained air voids in the concrete and could compromise the entrained air void system that reduces the freeze-thaw damage of the concrete. The stress caused by DEF expansion can cause the reinforcing steel to yield.

The damage caused by DEF looks similar to AAR and may be confusing in structures built prior to the introduction of restrictions on alkali aggregates (1986) however, inspectors should look for areas that are prone to DEF such as the following:

- Large concrete elements that are greater than 1.0 m in thickness
- Areas of large concrete elements that are exposed to water and humidity (splash zones, water crossings). Note: a relative humidity of 90% or above is sufficient to promote DEF expansion.
- Concrete placed prior to 1995.

The appearance of concrete affected by DEF can be found in Figure 2.5.4.15.

If a concrete element is suspected to have DEF (i.e., visual inspection “cracking”, other criteria above “size, age and exposure”), it is recommended to first begin by monitoring the crack propagation over time using pictures and tracking the rate of crack progress. If progress of cracking is rapid, then DEF can accurately be confirmed by extracting a small core to conduct microstructural analysis using scanning electron microscopy (SEM). This core 75mm-100mm in diameter and 100mm-200mm deep would need to be taken at the worst cracked area.

The results of the SEM would confirm the next steps, which could include further crack mapping, monitoring or repair.

Similar to alkali-aggregate reaction, there are no remedial measures to stop or reverse the process of deterioration; unfortunately, unlike AAR, sealing the surface to reduce the moisture ingress might not slow down DEF, as the existing moisture content in the concrete would be sufficient to promote DEF. Crack propagation causes existing cracks to widen and new cracks to form, which can not be bridged by sealers or other coating systems. The only known solution for

PART 2 – DETAILED VISUAL INSPECTION

concrete elements suffering from damage due to DEF is replacement at a significantly reduced service life (Reference 15-19).



Figure 2.5.4.15 DEF Pattern Cracks in Pier Footing

2.5.4.10 Surface Defects

The following surface defects in concrete are described herein:

- Stratification.
- Segregation.
- Cold Joints.
- Deposits - efflorescence, exudation, incrustation, stalactite.
- Honeycombing.
- Pop-outs.
- Abrasion and Wear.
- Slippery Surface.

Surface defects are not necessarily serious in themselves; however, they are indicative of a potential weakness in the concrete, and their presence should be noted but not classified as to severity, except for honeycombing and pop-outs.

PART 2 – DETAILED VISUAL INSPECTION

STRATIFICATION is the separation of the concrete components into horizontal layers in over-wetted or over-vibrated concrete. Water, laitance, mortar, and coarse aggregates occupy successively lower positions. A layered structure in concrete will also result from the placing of successive batches that differ in appearance.

SEGREGATION is the differential concentration of the components of mixed concrete resulting in non-uniform proportions in the mass. Segregation is caused by concrete falling from a height, with the coarse aggregates settling to the bottom and the fines on top. Another form of segregation occurs where reinforcing bars prevent the uniform flow of concrete between them.

COLD JOINTS are produced if there is a delay between the placement of successive pours of concrete, and if an incomplete bond develops at the joint due to the partial setting of the concrete in the first pour.

DEPOSITS are often left behind where water percolates through the concrete and dissolves or leaches chemicals from it and deposits them on the surface. Deposits may appear as the following:

- Efflorescence** a deposit of salts, usually white and powdery;
- Exudation** a liquid or gel-like discharge through pores or cracks in the surface;
- Incrustation** a hard crust or coating formed on the concrete surface;
- Stalactite** a formation hanging from the concrete surface, usually shaped like an icicle.

HONEYCOMBING is produced due to the improper or incomplete vibration of the concrete which results in voids being left in the concrete where the matrix failed to completely fill the spaces between the coarse aggregate particles. Figure 2.5.4.16 shows medium honeycombing on the corner between an abutment and wingwall.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.4.16 Severe Honeycombing on an Abutment and Wingwall

POP- OUTS are shallow, typically conical depressions, resulting from the breaking away of small portions of the concrete surface, due to the expansion of some aggregates or due to frost action. The shattered aggregate particle may be found at the bottom of the depression, with a part of the aggregate still adhering to the pop-out cone.

ABRASION is the deterioration of concrete brought about by vehicles or snow-plough blades scraping against concrete surfaces, such as, decks, curbs, barrier walls or piers.

WEAR is usually the result of dynamic and/or frictional forces generated by vehicular traffic, coupled with the abrasive influx of sand, dirt, and debris. It can also result from the friction of ice or water-borne particles against partly or completely submerged members. The surface of the concrete appears polished.

SLIPPERY CONCRETE SURFACES may result from the polishing of the concrete deck surface by the action of repetitive vehicular traffic.

There are no severity descriptions given for slippery concrete surfaces as this is a serious and potentially hazardous situation. Where evidence of slippery concrete deck surface is noted the Operations and Maintenance Offices shall be notified.

PART 2 – DETAILED VISUAL INSPECTION

The following table provides a summary of condition state for each Concrete - Substructures and Superstructure defect.

2.5.4.11 Defect Tables
Table 2.5.4.1: Concrete - Substructures and Superstructures Defect Definitions

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Scaling	Local flaking/loss of surface portion of concrete or mortar due to freeze-thaw		
	Up to 5 mm depth	6 - 10 mm depth	> 10 mm depth
Disintegration	Physical deterioration or breaking down of the concrete into small fragments		
			All
Erosion	Deterioration of concrete brought about by water-borne sand and gravel particles scrubbing against surfaces		
			All
Corrosion of Reinforcement	Deterioration of reinforcement by electrolysis		
	Due to drains/chairs	Rust stains from reinforcement	Exposed reinforcement with rust
Delamination	Discontinuity of the surface concrete which is substantially, but not completely detached from concrete below or above it.		
			All
Spalling	Fragments which have been detached from a larger concrete mass		
			All
Cracking ^{2, 3, 4}	Linear fracture which extends partly or completely through the member.		
	< 0.3 mm	0.3 - 1.0 mm wide	> 1.0 mm wide
Alkali-Aggregate Reaction	Aggregates react adversely with the alkalis in cement to produce a highly expansive alkali-silica gel		
	Hairline pattern cracks < 0.1 mm	Narrow pattern cracks 0.1 - 0.3 mm wide	Medium-wide pattern cracks > 0.3 mm wide

PART 2 – DETAILED VISUAL INSPECTION

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Delayed Ettringite Formation	Concrete that has been cured at temperatures above 70 degrees Celsius have delayed ettringite formation which results in progressive map cracking.		
	Hairline pattern cracks < 0.1 mm	Narrow pattern cracks 0.1 - 0.3 mm wide	Medium-wide pattern cracks > 0.3 mm wide
Honeycombing	Produced due to the improper or incomplete vibration of the concrete which results in voids being left in the concrete where the mortar failed to completely fill the spaces between the coarse aggregate particles		
	Holes up to 25 mm diameter	Holes 25 - 50 mm diameter	Holes more than 50 mm diameter
Pop-Outs	Shallow conical depressions resulting from the breaking away of small portions of the concrete surface, due to the expansion of some aggregates due to frost action.		
	Holes up to 25 mm diameter	Holes 25 - 50 mm diameter	Holes more than 50 mm diameter
Stratification	Separation of concrete into layers prior to hardening, due to over- vibration.		
		ALL	
Segregation	Concrete not uniform due to falling concrete (poor placement)		
		ALL	
Cold Joints	Caused by hardened concrete prior to the next adjacent pour		
		ALL	
Deposits	Water seeped through concrete, leaching chemicals and depositing them on the surface - efflorescence		
		ALL	
Abrasion	Wearing caused by vehicles or snow-plough blades		
		ALL	
Wear	Result of dynamic and/or frictional forces generated by vehicular traffic, coupled with the abrasive influx of sand, dirt and debris		
		ALL	
Slippery Concrete	Smooth surface resulting from the polishing of the concrete deck surface by the action of repetitive vehicular traffic		

PART 2 – DETAILED VISUAL INSPECTION

DEFECT	CONDITION STATE		
	GOOD (LIGHT)	FAIR (MEDIUM)	POOR (SEVERE)
Surface		ALL* include suspected performances deficiency of "slippery surface"	
Active Wet Areas	Concrete surface is wet or damp due to salt contaminated water		
		Wet but no cracks	Wet with cracks
For retaining wall structure only (including RSS walls, notes 7)			
Joints between precast concrete panels as constructed (notes 8)	Difference up to $\pm 20\%$	Difference up to $\pm 50\%$	Larger than 50%
		Perform structural condition survey if > 50% wall is in fair or poor condition	

Notes:

- 1) Excellent Condition – No observed material defects. Or joints are the same as constructed.
- 2) For all calculations, the actual area shall be determined for areas containing numerous cracks (i.e., pattern cracks, map cracks).
- 3) For isolated cracks, 4 m of crack length is equal to 1 square metre of defect repair area.
- 4) If shear cracks are found at girder ends, an evaluation should be done. If cracks are wide, the inspector should mark "URGENT" for the timeframe of the evaluation. As with other potentially unsafe conditions, the bridge owner should be notified if these cracks are noticed.
- 5) For superstructure: if area of deterioration in poor condition state >5%, perform Deck Condition Survey
- 6) For substructure: if area of deterioration in poor condition state >10%, perform Condition Survey
- 7) For low and medium performance RSS walls, condition state table is not available at this time and the inspection should be done using the judgement of the inspector.
- 8) Constructed joint in Reinforced Soil Structure is 19 mm.

Table 2.5.3.2: Concrete - Top of Deck Asphalt Defect Definitions

Based on Visual Inspection of Asphalt			
Defects	Good Condition	Fair Condition	Poor Condition
Top-down or bottom-up asphalt defects.	Top-Down	Bottom-Up	Bottom-Up

PART 2 – DETAILED VISUAL INSPECTION

Cracks in asphalt	Light and medium isolated cracks	Wide isolated cracks include: i) longitudinal cracks: - above location of voids, - edge of beam flanges, - joint between precast units, - construction joints, etc., or ii) transverse cracks)	All Wide Pattern cracks e.g.: - map, - alligator, - radial, and or - edge cracking
Local protrusions in asphalt		✓	
Full Depth Potholes in asphalt			✓
Bond Defects in asphalt e.g., rippling, loss of bond	✓		
Surface Defects in asphalt e.g., ravelling, flushing, slippery surface)	✓		
Surface Distortions in asphalt e.g., wheel track rutting	✓		

Notes:

- 1) Excellent Condition – No observed material defects
- 2) For all calculations, the 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 metre of defect repair area.
- 4) If a bridge has been recently repaved without rehabilitating the deck, the inspector must estimate the condition of the concrete deck using other means. This would include using previous inspection information, the age of the waterproofing, deck condition survey data, etc.

2.5.5 Coatings

This section describes coating material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.4), then followed by photos to visually show sample defects.

Coating defects are not necessarily serious in themselves; however, they are indicative of a potential weakness in the coating and eventual loss of protection for the surface coated. No criteria are given for the severity of material defects in coatings; therefore, they do not need to

PART 2 – DETAILED VISUAL INSPECTION

be classified as to severity. However, their presence and the area affected should be noted and recorded.

There are several types of material defects that commonly occur in coatings (References 5 to 8), which can be grouped into the following three categories:

a) Coating Related Defects

These are defects which are related to the basic chemistry or composition of the coating and reaction of the coating materials with each other and the environment. Common defects of this type are:

- Checking or Crazing
- Cracking
- Alligatoring
- Chemical Attack
- Chalking

b) Adhesion Related Defects

These are defects which are usually a result of incorrect coating selection, contaminated substrate, or improper surface preparation. Common defects of this type are:

- Undercutting
- Blisters
- Intercoat Delamination
- Peeling
- Underfilm Corrosion

c) Application Related Defects

These are defects which are usually a result of the improper application of the coating. Common defects of this type are:

- Bridging
- Edge Defects
- Shadows
- Overspray
- Pin holing
- Runs
- Sags
- Pinpoint Rusting

2.5.5.1 Coating-Related Defects

PART 2 – DETAILED VISUAL INSPECTION

CHECKING or CRAZING usually appears as a fine system of minute cracks in a checkerboard pattern. This is a surface defect and does not necessarily penetrate the full depth of the coating. They are usually inherent in the coating as some pigments combined with some vehicles will tend to cause checking or crazing to occur. They may also be caused by the weathering process, including wetting and drying, heating and cooling, exposure to sunlight and contraction of the coating as it dries or cures Figure 2.5.5.1.



Figure 2.5.5.1 Checking

CRACKING may result from the effects of weathering or continued polymerisation of the coating materials over time. An oxidizing or catalyzed coating applied over a very smooth surface may crack due to shrinkage and poor adhesion to the substrate. Cracking is an extension of the checking process and usually occurs in a linear pattern and penetrates completely through the coating, Figure 2.5.5.2. The cracked coating tends to spall off exposing bare substrate.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.5.2 Cracking

ALLIGATORING occurs if a hard, brittle or oxidizing top coat is applied over an extensible base coat, such as an alkyd over an asphalt base. As the surface hardens and shrinks, very large irregular checks, usually several centimetres across, are formed on the surface in a characteristic alligator pattern but do not go all the way through the coating. If not over-coated with compatible material; then, the mechanism will continue until it completely penetrates to the substrate, Figure 2.5.5.3.

PART 2 – DETAILED VISUAL INSPECTION

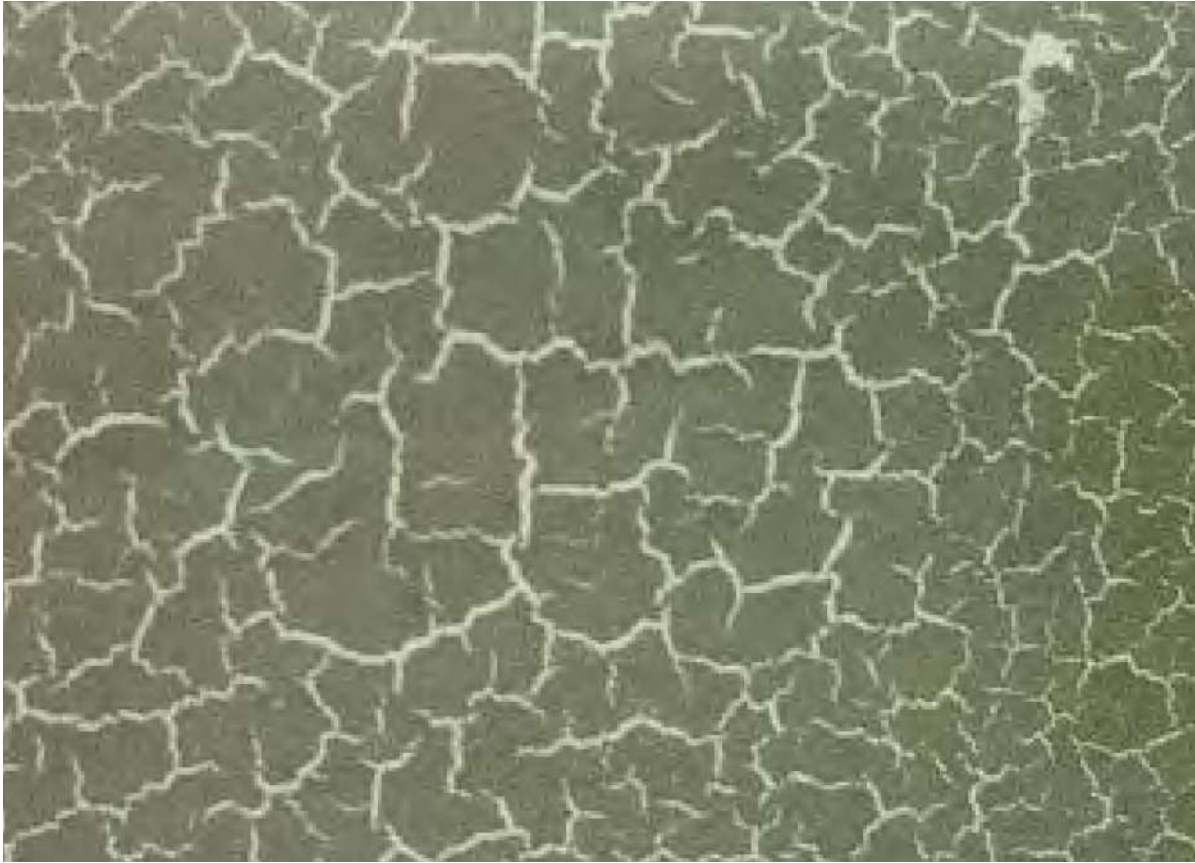


Figure 2.5.5.3 Alligatoring (Typical Mud Crack Pattern)

CHEMICAL ATTACK results as some coating materials may react adversely with some air-borne chemicals and pollutants, or as a result of accidental spillage. Oil base coatings such as alkyds are subject to damage by alkaline chemicals, Figure 2.5.5.4.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.5.4 Chemical Attack

CHALKING is a surface phenomenon of some coatings that results from exposure to the action of solar radiation and the processes of weathering over a period of time. This results in a chalky or powdery appearance of the coating. It occurs because many basic resins will react with sunlight and many pigments will accelerate the process of weathering away of the resin binder between the pigment particles leaving the pigment particles free on the surface. Chalking is usually a surface defect, and the coating is intact below the chalky surface; however, chalking can progress, and the thickness of sound coating reduced to the point where the substrate is exposed.

2.5.5.2 Adhesion-Related Defects

UNDERCUTTING is the spreading of corrosion underneath the coating from a break in the coating. It is usually caused by poor surface preparation and the application of the coating over surfaces which contain mill scale or rust; or which have oil, grease or dirt, and otherwise improperly cleaned surfaces. Undercutting can also be caused by application of the coating to surfaces that are very smooth or non-porous resulting in poor adhesion of the coating. Undercutting is also promoted by high moisture vapour permeability of the coating and penetration by oxygen and salts, Figure 2.5.5.5.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.5.5 Undercutting

BLISTERS are dome shaped projections in paints arising from the detachment of one coat from another or from the substrate. It is generally caused either by solvents which are trapped within or under the paint film, or by water which is drawn through the paint film by the osmotic forces exerted by hygroscopic salts at the paint/substrate interface, Figure 2.5.5.6.

PART 2 – DETAILED VISUAL INSPECTION

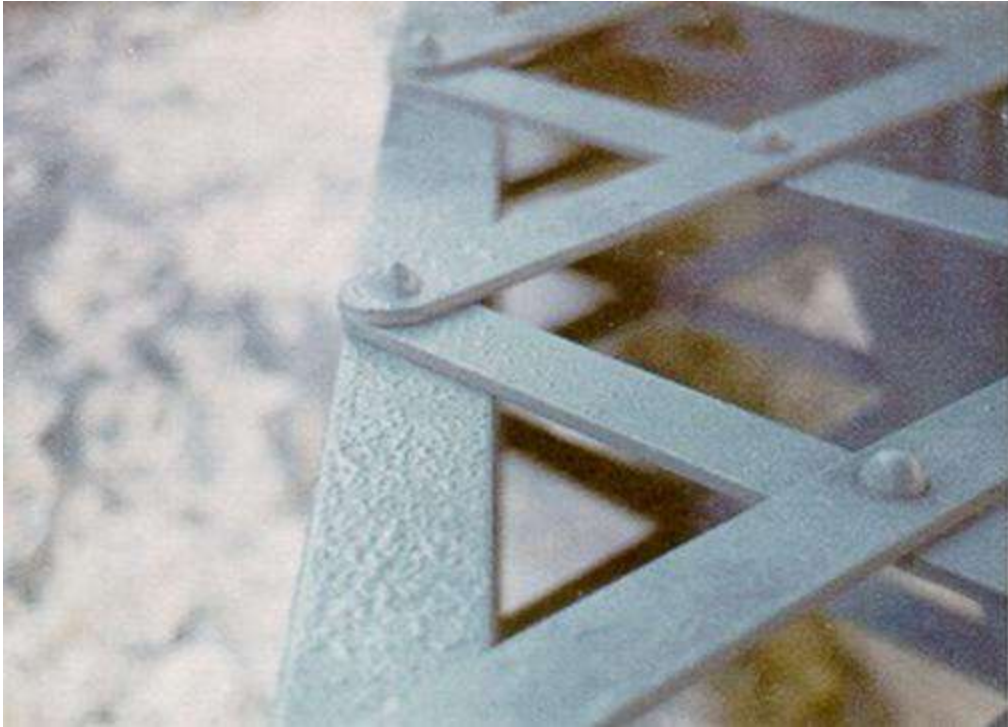


Figure 2.5.5.6 Blisters

INTERCOAT DELAMINATION is where one coat separates from another and is usually related to poor coating application over contaminated surfaces or to too long a drying or curing period between coats, Figure 2.5.5.7.

PART 2 – DETAILED VISUAL INSPECTION

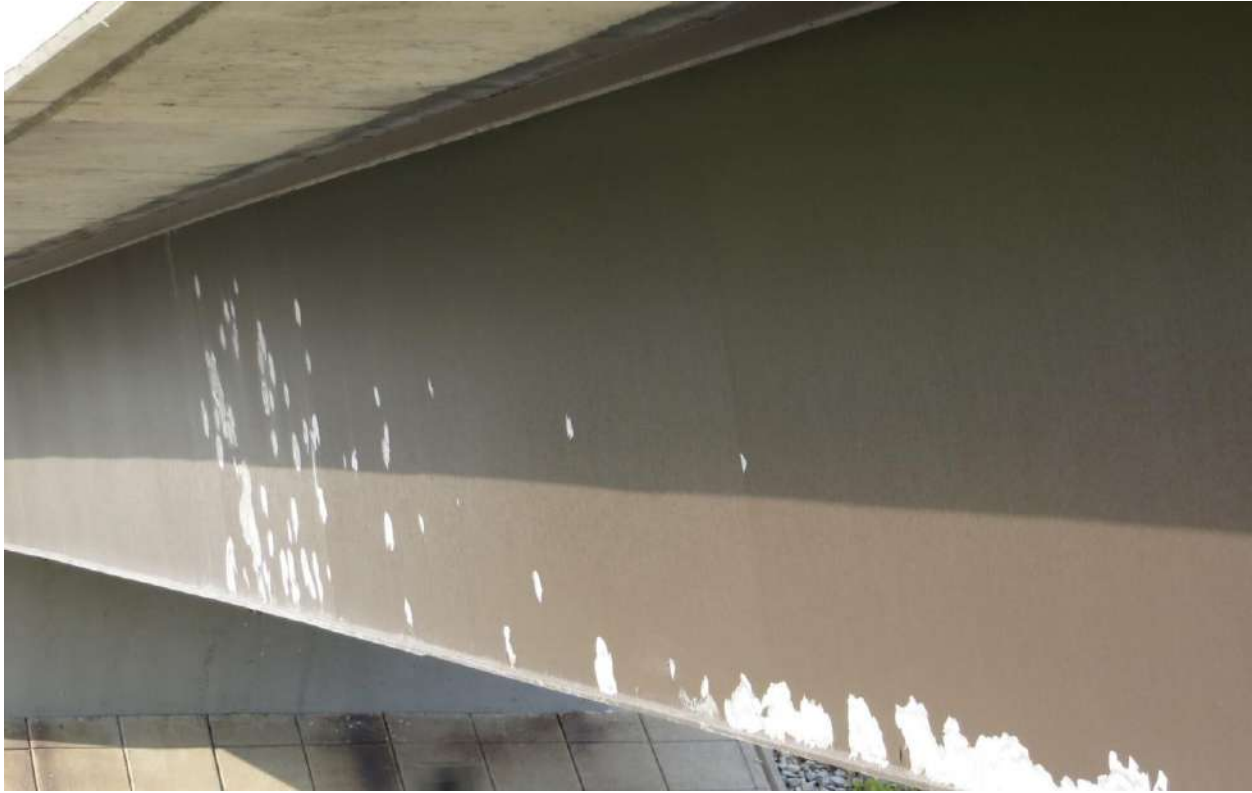


Figure 2.5.5.7 Intercoat Delaminations

PEELING is also a result of poor adhesion of the coating either from the substrate or from a previously applied coating. It is related to the tensile strength of the coating film itself where, if the tensile strength of the film is greater than the adherence to the surface; then, the coating will tend to peel. Peeling between coats is usually caused by contamination of the surface of the previous coat, Figure 2.5.5.8.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.5.8 Peeling

UNDERFILM CORROSION is the building up of corrosion under the coating without the help of a break in the coating. It is prevalent in coatings which oxidize on the surface, such as oil base and alkyd coatings. These oxidize over time to a point where they become porous to moisture, oxygen, and chloride ions. This coating failure is promoted by poor surface preparation, substrate profile and surface contamination.

2.5.5.3 Application-Related Defects

BRIDGING across inside corners where debris has accumulated occurs if the debris is not properly cleaned off before the coating is applied. The coating, upon curing, may shrink sufficiently to bridge over the area resulting in voids under the coating. Subsequent penetration by moisture and oxygen will result in coating failure.

EDGE DEFECTS are a result of the improper or insufficient application of coatings to sharp edges and corners. The coating will tend to pull away from sharp edges and corners due to surface tension of the coating. This results in a thinner coating in these areas and, consequently, loss of film thickness and protection, Figure 2.5.5.9.

PART 2 – DETAILED VISUAL INSPECTION

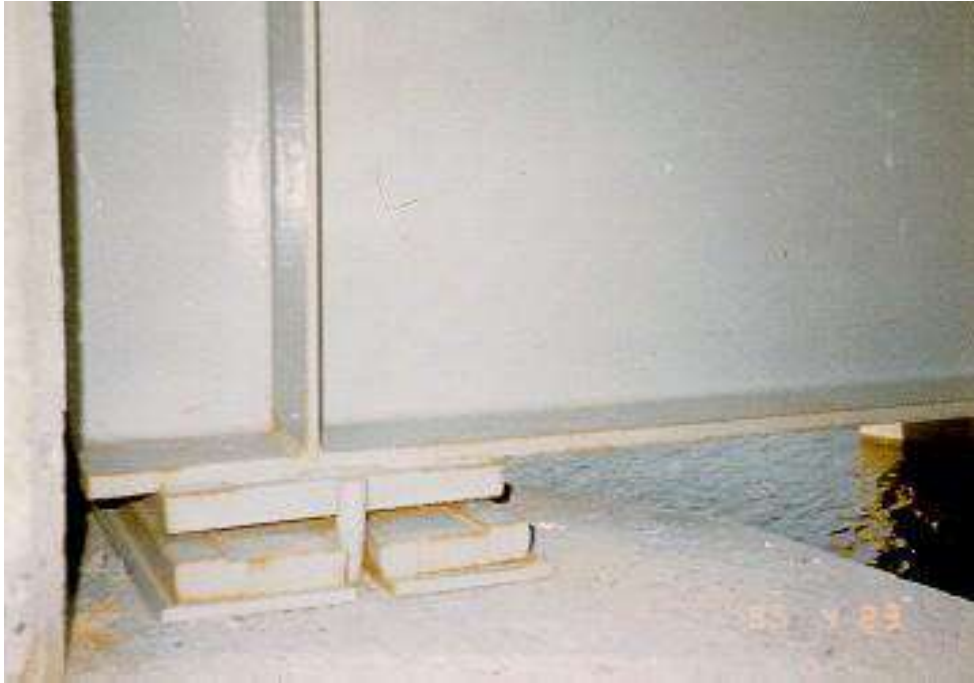


Figure 2.5.5.9 Edge Defects

SHADOWS often result around rivets, bolts, welds, and at other areas where there are abrupt changes in an otherwise smooth surface, and where the coating is not applied in a sufficient number of different directions resulting in incomplete coverage.

OVERSPRAY occurs when paint particles fall on the surface outside the normal spray pattern. The result is a dry spray as these particles are usually dry by the time they reach the surface. The resulting appearance is an area which is rough and dull and does not have the same sheen as other areas where the coating is properly applied. The dry spray will absorb solvent from the subsequent coats resulting in poor adhesion. Overspray areas are also typically more porous and, consequently, early coating failure can result.

PINHOLING can be caused by holding the spray gun too close to the surface so that air bubbles are entrained into the coating creating voids throughout the depth of the coating. If pinholing occurs in one coat; then, it will also tend to occur in subsequent coats, thus providing a passage through the voids to the substrate. Pinholing usually occurs in fast drying coatings, Figure 2.5.5.10.

PART 2 – DETAILED VISUAL INSPECTION



Figure 2.5.5.10 Pinholing

RUNS are a downward movement of a paint film in rivulets caused usually by overthinning, slow thinners, and/or holding the spray gun too close to the surface and depositing too much paint at one time. The perimeter of the run is often accompanied by pinholes, Figure 2.5.5.11.

SAGS are heavy thicknesses of paint which have slipped and formed curtains on the surface. They are caused by the same things that lead to runs, Figure 2.5.5.11.