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- Drones shall not take off or land within highway or freeway medians, as this poses a driver distraction and restricts safe emergency-landing options.
- Drones operating without the use of on-board optical navigation in GPS denied areas should operate with increased caution and expertise. Greater pilot skill and planning is required, and when feasible, you should maintain an additional spatial buffer from the structure to avoid collision.
- All active migratory bird nests are legally protected from disturbance or destruction under the Migratory Bird Convention Act (1994). Maintain a safe flying distance from birds and their nests and avoid flying around structures known to have nests during peak breeding season (May – July) when possible. It may be necessary to revisit the site with the drone later if proper data cannot be collected without disturbing a nesting bird.

### 2.1.4.3 Infrared Thermography (Thermal Cameras)

Inspectors can choose to use thermal cameras to supplement their estimates of elements condition's that are not within arms reach and would have been estimated as per Section 1.1.3.4 of Part 1. The quantities accounted for by using this technology can be included in the inspection but only for this situation. For further information on infrared thermology please see the MTO's Structure Rehabilitation Manual, Part 1.

### 2.1.4.4 Special Access Equipment Requirements

Certain locations on a structure may not be accessible for inspection without special equipment. This special access equipment may only be required on some structures periodically for Enhanced OSIM inspections and not during all biennial inspections (see Part 1, Section 1.1.3.5 **Error! Reference source not found.**). Inspectors should prearrange with the appropriate parties, for the use of the special equipment such as:

- Extension or folding ladder (3.5 m)
- Boat or barge
- Scaffolds - mobile, cable supported or stationary
- Scissors Lift
- Truck mounted inspection bucket on a hydraulically operated boom off a truck
- "Cherry Picker"
- "BridgeMaster"
- Lane closures

## 2.1.5 Systematic Inspection Procedures

### 2.1.5.1 Preparation Prior to Field Inspection

The inspector shall:

- Familiarize themselves with the details of the structure and its history. Obtain and review existing records of the structure prior to field work, including issued for construction (IFC) and "as-built" drawings, previous inspection reports, correspondence and details of

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repairs, work history (rehabilitations or modifications) carried out after original construction. It is often useful for the inspector to take to the field a one- or two-page summary of general inventory data and information on previous rehabilitation work. See Part 2, Section 2.8 for a sample of this type of inventory data.

- Prepare inspection forms, (See Part 2, Section 2.8) for each structure to be inspected. An individual inspection report can be built up, for any structure, by selecting the elements required to completely describe the structure under consideration (See Part 2, Section 2.2).
- Record dimensions and calculate the quantities for the bridge elements under consideration as described in Part 2, Section 2.4. This information should be summarized starting on Page 4 of the Sample Inspection Form under the “Element Data” section of the inspection form (See Part 2, Section 2.8.7). In certain cases, elements shall be divided into sub-elements as indicated in Part 2, Section 2.2.
- Decide the time schedule for the inspection and any required special equipment, including traffic protection devices.
- Plan for special equipment and traffic control services, if required.
- Obtain permission from the railway company if the bridge is over railway tracks, and mobile platforms or other special equipment is going to be used in the track area. (Note: most rail companies require railway certified flagger’s to be on site for all inspections within their ROW. All flagging applications are typically coordinated by the Structures Office; applications need 8-12 weeks for processing).

### 2.1.5.2 Site Inspection

The inspector shall:

- Complete a brief overview inspection of the site to:
  - Assess the overall integrity of the structure and identify areas where more detailed examination may be required, based on structure type and material, articulation and span arrangement
  - Observe the bridge under truck loading and identify any abnormal flexibility, deflections or noises (rattling or vibration of members, etc.)
  - Look for abnormal deflections, settlements or rotations by looking along the rail or barrier wall or girder flanges or other members
  - Identify obstacles that may either interfere with the inspection or indicate a need for additional special equipment.
- If traffic control is needed, discuss inspection procedures with the foreman of the traffic control crew so that adjustments, lane closures and traffic detours, etc. are timed to suit inspection needs.
- Check that all signs, temporary barriers, protective screens, etc. are in place.
- Once the site has been secured, the inspection of each element (as selected in Part 2, Section 2.1.5.1) shall proceed in a systematic fashion (top to bottom of structure or

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bottom to top) by completing the various parts of the inspection form. (See Part 2, Section 2.8). Material defects, performance deficiencies, maintenance needs, and timing for work shall be noted for each element.

- The inspector has the choice of inspecting all the spans of a structure together or “span by span”. If the condition of each span varies considerably from one span to the next, then the inspector should inspect each span separately. Element data would need to be recorded separately for each span. Note that if the “span by span” option is chosen, element dimensions and quantities should be recorded for the span under consideration only.
- In general, if several elements of the same type exist for one structure (e.g., Piers, abutments), one “Element Data” table can be used unless the condition of each of the elements varies considerably. If element condition does vary, separate “Element Data” tables should be used, and the “Location” part of the inspection form should be filled in to distinguish one element from the next (e.g., North Abutment and South Abutment).
- Sub-elements, as defined in Part 2, Section 2.2, should be used in dividing up the structure, calculating quantities during the inspection.
- If element data are changed or added in the field, element quantities must be adjusted accordingly.
- Record observations and make sketches where appropriate. It is not unreasonable to document in a report that there are no known deficiencies, to let future inspectors know that deficiencies they are seeing are new.
- Take photographs to adequately describe the structure and the defects found. In general, the following photographs should be taken:
  - One photograph which clearly shows the deck cross-section and features such as number of traffic lanes, curbs and sidewalks, medians, and railing system. Note: This photograph is normally taken from the approach roadway looking along the length of the bridge.
  - One photograph of the elevation of the structure which clearly shows the number of spans and superstructure type.
  - One photograph of the underside (soffit) which shows the type and number of main superstructure element(s).
  - Individual photographs should be taken of all areas in a poor condition state (areas with severe defects and deterioration). These photographs should be taken at sufficiently close range such that the type, location and extent of the defects are clearly visible and apparent; a supplemental photograph from further out showing perspective of the defect is also suggested. Note: Where there are

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no areas of severe deterioration in an element, a photograph should be taken showing a typical area which represents the worst condition state in that element.

- Check if the structure and its elements are built in accordance with existing available information and record any significant discrepancies, so that existing records can be revised accordingly. If changes have taken place as the result of rehabilitation work, element dimensions and quantities should be updated.
- Identify additional detailed investigations that are required.

### 2.1.5.3 Post Inspection Procedures

The inspector shall:

- Ensure that the appropriate action is taken (notify bridge owner immediately) for any critical structural defects or deficiencies (i.e., fatigue cracks in steel, imminent deck punch through, etc.) and all other unsafe conditions that are discovered in the field,
- Make sure all inspection equipment and temporary traffic control devices are removed from the site and the site is left in workmanlike order,
- Ensure the appropriate follow-up action is taken for any Suspected Performance Deficiencies noted during the inspection,
- Structural office shall submit Maintenance Needs list to Maintenance Office for action,
- Ensure additional investigations are initiated in the timeframe recommended,
- Write all necessary follow-up correspondence and reports.

## 2.2 ELEMENT LIST

The first step in performing a detailed visual inspection is to divide the structure into individual elements. Bridge components, as described in Part 1 of this manual, have been placed into element groups where appropriate. Although primary, secondary, and auxiliary components are described in Part 1, for inspection purposes, no distinction is made between these types of components. Table 2.2.1 lists the standard elements available for each element group. Table 2.2.1 also gives the standard unit of measurement for quantities for each element and the applicable Condition State section number for categorising material defects. Table 2.2.1 lists the elements that are typically required/available for the most common types of structures. It should be noted that this list is for guidance only. The actual element list should be customised to suit the structure being inspected. For an explanation of what components of the structure are included under each element category, refer to Tables in Part 2, Section 2.4. The following general guidelines should be followed when selecting elements:

- Similar element types, within the same Element Group, should be grouped together, and a separate “Element Data” table should be filled out for each element type (e.g., similar bearing types, diaphragm types, etc.).

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- If element condition varies for similar element types, separate “Element Data” tables should be used and the “Location” part of the inspection form (see Sample Inspection Form in Section 2.8.8) should be filled in to distinguish one element from the next (e.g., North Abutment, South Abutment, East pier, portal bracing, etc.)
- Elements should be divided into “sub-elements”, as shown in Table 2.2.1. The description and when to use sub-elements is given in Tables in Section 2.4.1. A separate “Element Data” table should be filled out for each sub-element. The following sub-elements should be used:
  - Total deck length consists of the distance between support centrelines and the overhang, which is the distance from the centre of bearing to the end of deck (see Figure 2.4.2.1 (a) and Figure 2.4.2.2 (a)).
  - For structures with expansion joints, an “End” element must be used for the superstructure element(s) (deck, girder, etc.). Each “End” shall be rated separately from the “Middle” portion of that element. An “end” element has a default length of 2m, which can be adjusted between 1 to 3 m, dependent upon the extent of deterioration noted in the field. For elements with end and middle sub-elements, the total length is the sum of both sub-elements.
  - For deck soffits, “Exterior” cantilevers shall be rated separately from the “Interior” of the soffit. See Figure 2.4.2.4 for definition of Cantilever
  - For diaphragms, floor beams and stringers, “End” and “Intermediate” sub-elements shall be used.
  - For barrier/parapet walls, the “Interior” face shall be rated separately from the “Exterior” face.
- At this stage, a decision should also be made regarding the overall process for inspecting the bridge. Part 2, Section 2.1.5.2 describes the criteria for selecting whether the bridge should be inspected as a whole or span by span.
- For several elements, (i.e. curbs, barriers), their length includes a portion beyond the superstructure on the approach. The length of the “approach” should be taken as the length of the approach slab or the length to the end of the wingwalls (whichever is greater). For modular bridges, the ramps are taken as approaches.
- The element list in Table 2.2.1 includes the most common bridge components. If a particular component is not found in the element list, the most appropriate (closest match) element should be selected from the list. The “Location” part of the inspection form can also be used when trying to identify non-standard elements.

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Table 2.2.1 Element List and Condition State Cross Reference

Element Group	Element Name <sup>f, g, h</sup>	Unit for Quantity <sub>a, b, c, d</sub>	Applicable Condition State Section Number <sup>e</sup>
Abutments	Abutment Walls	m <sup>2</sup>	2.5.4, 2.5.14, 2.5.15
	Ballast Walls	m <sup>2</sup>	2.5.4, 2.5.14, 2.5.15
	Bearings	Each	2.5.9
	Wingwalls	m <sup>2</sup>	2.5.4, 2.5.14, 2.5.15
Accessories (Attachments, Signs, and Type I Bridge Mounted Signs)	Bridge Mounted Sign Supports <sup>i</sup>	Each	2.5.20
	Electrical	Each	2.5.20
	Noise Barriers	m <sup>j</sup>	2.5.20
	Other	Each	2.5.20
	Signs	Each	2.5.20
	Utilities	Each	2.5.20
Approaches	Approach Slabs	m <sup>2</sup>	2.5.4
	Barriers	m <sup>j</sup>	2.5.4
	Curb and Gutters	m	2.5.4
	Drainage System	Each	2.5.12
	Sidewalk / Curbs	m <sup>2</sup>	2.5.4
	Wearing Surface	m <sup>2</sup>	2.5.4, 2.5.8
	Barriers	Barrier / Parapet Walls	m <sup>2</sup>
Hand Railings		m <sup>j</sup>	2.5.6, 2.5.7
Posts		Each	2.5.4, 2.5.6, 2.5.15
Railing Systems		m <sup>j</sup>	2.5.4, 2.5.6, 2.5.7, 2.5.15
Beams/Main Longitudinal Elements	Diaphragms (built-up)	Each	2.5.6, 2.5.15
	Diaphragms (Monolithic)	m <sup>2</sup>	2.5.4
	Floor Beams	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.15
	Girders	M <sup>2</sup>	2.5.4, 2.5.6, 2.5.15
	Inside Boxes (Sides & Bottom)	M <sup>2</sup>	2.5.4, 2.5.6
	Stringers	Each	2.5.4, 2.5.6, 2.5.15
Bracing	Bracing	Each	2.5.6, 2.5.15
Coatings	Railing Systems / Hand Railings	m <sup>2</sup>	2.5.5
	Structural Steel	m <sup>2</sup>	2.5.5
Culverts	Barrels	m <sup>2</sup>	2.5.4, 2.5.8, 2.5.7, 2.5.13
	Inlet Components	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.7, 2.5.13
	Outlet Components	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.7, 2.5.13
Decks	Deck Top	m <sup>2</sup>	2.5.4, 2.5.15
	Drainage Systems	Each	2.5.12
	Soffit – Inside Boxes	m <sup>2</sup>	2.5.4, 2.5.15
	Soffit – Thick Slab	m <sup>2</sup>	2.5.4, 2.5.15
	Soffit – Thin Slab	m <sup>2</sup>	2.5.4, 2.5.15
	Wearing Surface	m <sup>2</sup>	2.5.8
Embankments & Streams	Embankments	Each	2.5.17
	Slope Protection	Each	2.5.18
	Streams and Waterways	All	2.5.19
Foundation	Foundation (below ground level)	N/A	Rate performance only.
Joints	Armouring / Retaining Devices	m	2.5.10
	Concrete End Dams	m <sup>2</sup>	2.5.4
	Seals / Sealants	Each	2.5.11
Piers	Bearings	Each	2.5.9

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<b>Element Group</b>	<b>Element Name<sup>f, g, h</sup></b>	<b>Unit for Quantity<sup>a, b, c, d</sup></b>	<b>Applicable Condition State Section Number<sup>e</sup></b>
	Caps	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.14, 2.5.15
	Shafts / Columns / Pile Bents	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.14, 2.5.15
Retaining Walls	Barrier Systems on Walls	m <sup>2</sup>	2.5.4, 2.5.15
	Railing Systems	m <sup>j</sup>	2.5.6, 2.5.7, 2.5.15
	Drainage Systems	All	2.5.12
	Walls	m <sup>2</sup>	2.5.4, 2.5.6
Sidewalks / Curbs	Curbs	m <sup>2</sup>	2.5.4, 2.5.15
	Sidewalks and Medians	m <sup>2</sup>	2.5.4, 2.5.15
Trusses / Arches	Bottom Chords	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.15
	Connections	Each	2.5.6, 2.5.15
	Top Chords	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.15
	Verticals / Diagonals	m <sup>2</sup>	2.5.4, 2.5.6, 2.5.15

- Notes: a) For “All”, place the entire component (100%) in one condition state.  
b) For “Each”, give the number of occurrences of the component in each state.  
c) For cracks in concrete, estimate repair area (4m of crack = 1 sq. m of repair).  
d) For cracks in steel, estimate required repair area.  
e) The condition states given in Part 2 Section 2.5 are typical for element. Use appropriate section for applicable material.  
f) Sub-elements (End/Middle) to be used for the following elements at expansion joint locations: Deck Top, Girders, Inside Boxes  
Sub-elements (End/Intermediate) to be used for the following elements at expansion joint locations: Floor Beams, Stringers, Bracing and Diaphragms  
Sub-elements (End/Interior/Exterior) to be used for Soffits  
Sub-elements (Interior/Exterior) to be used for Barrier/Parapet Walls  
g) For an explanation of which bridge components are included in each element, see the tables in Section 2.4.1  
h) Similar element types should be grouped together (e.g., I-girders, x-frames, etc.)  
i) Optional element. Not required for MTO use. MTO to refer to OSSIM  
j) For these elements that are inspected by linear metre, a defect in the post shall be assumed to affect the tributary area for that post.

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Table 2.2.2 Element List for Each Bridge Type

Element Name	Sub-Element	Slab on Girder		Post-Tensioned Deck		Solid Slab	Truss	Rigid Frames	Culverts
		Steel	Concrete	Rectangular Voids	Circular Voids				
<b>Element Group: ABUTMENTS</b>									
Abutment Walls		X	X	X	X	X	X	X	
Ballast Walls		X	X	X	X	X	X		
Bearings		X	X	X	X	X	X		
Wingwalls		X	X	X	X	X	X	X	X
<b>Element Group: ACCESSORIES (ATTACHMENTS AND SIGNS)</b>									
Bridge Mounted Sign Supports		?	?	?	?	?	?	?	?
Electrical		?	?	?	?	?	?	?	?
Noise Barrier		?	?	?	?	?	?	?	?
Other		?	?	?	?	?	?	?	?
Signs		?	?	?	?	?	?	?	?
Utilities		?	?	?	?	?	?	?	?
<b>Element Group: APPROACHES</b>									
Approach Slabs		X	X	X	X	X	X	X	
Barriers		?	?	?	?	?	?	?	?
Curb & Gutters		?	?	?	?	?	?	?	?
Drainage System		X	X	X	X	X	X	X	X
Sidewalk/Curb		?	?	?	?	?	?	?	?
Wearing Surface		X	X	X	X	X	X	X	X
<b>Element Group: BARRIERS</b>									
Barrier / Parapet Walls	Interior / Exterior faces	X or	X or	X or	X or	X or	X or	X or	X or
Hand Railings		?	?	?	?	?	?	?	?
Posts		?	?	?	?	?	?	?	?
Railing Systems		X	X	X	X	X	X	X	X
<b>Element Group: BEAMS / MAJOR LONGITUDINAL ELEMENTS (MLEs)</b>									
Diaphragms	End	X	X						
	Intermediate	X	?						
Floor Beams	End						X		
	Intermediate						X		

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Element Name	Sub-Element	Slab on Girder		Post-Tensioned Deck		Solid Slab	Truss	Rigid Frames	Culverts
		Steel	Concrete	Rectangular Voids	Circular Voids				
Girders		X or	X or						
	End / Middle	X*	X*						
Inside Boxes		X or	X or	X or					
	End / Middle	X*	X*	X*					
Stringers	End						X		
	Intermediate						X		
Bracing	End						X		
	Intermediate						X		
<b>Element Group: COATINGS</b>									
Barrier Systems / Hand Railings		?	?	?	?	?	?	?	?
Structural Steel		X†					X†		X†
	End / Middle	X*					X*		X*
<b>Element Group: CULVERTS</b>									
Barrels									X
Inlet Components									X
Outlet Components									X
<b>Element Group: DECKS</b>									
Deck Top		X	X	X	X	X	X	X	
Drainage System		?	?	?	?	?	?	?	
Soffit – Inside Boxes		X or	X or	X or					
	End / Middle	X*	X*	X*					
Soffit – Thick Slab	End			X*	X*	X*			
	Exterior			X	X	X		X	
	Interior			X	X	X		X	
Soffit – Thin Slab	End	X*	X*				X*		
	Exterior	X	X				?		
	Interior	X	X				X		
Wearing Surface		X	X	X	X	X	X	X	
<b>Element Group: EMBANKMENTS &amp; STREAMS</b>									
Embankments		X	X	X	X	X	X	X	X
Slope Protection		X	X	X	X	X	X	X	X
Streams & Waterways		X^	X^	X^	X^	X^	X^	X	X

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Element Name	Sub-Element	Slab on Girder		Post-Tensioned Deck		Solid Slab	Truss	Rigid Frames	Culverts
		Steel	Concrete	Rectangular Voids	Circular Voids				
<b>Element Group: FOUNDATIONS</b>									
Foundation (Below Ground Level)		X	X	X	X	X	X	X	X
<b>Element Group: JOINTS</b>									
Armouring / Retaining Devices		?	?	?	?	?	X		
Concrete End Dams		?	?	?	?	?	X		
Seals / Sealants		?	?	?	?	?	X		
<b>Element Group: PIERS (multi-span structures)</b>									
Bearings		X	X	?	?	?	X		
Caps		?	?	?	?	?	?	?	
Shafts / Columns / Pile Bents		X	X	X	X	X	X	X	
<b>Element Group: RETAINING WALLS</b>									
Barrier Systems on Walls		?	?	?	?	?	?	?	
Walls		?	?	?	?	?	?	?	
<b>Element Group: SIDEWALKS / CURBS</b>									
Curbs		?	?	?	?	?	?	?	
Sidewalks / Medians		?	?	?	?	?	?	?	
<b>Element Group: TRUSSES / ARCHES</b>									
Bottom Chords							X		
Connections							X		
Top Chords							X		
Verticals / Diagonals							X		

Notes:

- X = Element Required
- X or = Element or subsequent element must be chosen (only 1 of the choices needs to be selected; e.g., Barrier Wall OR Railing System)
- X\* = Only applicable when expansion joints are present.
- X^ = Only applicable if structure is a water crossing.
- X† = Only applicable if not ACR steel.
- ? = Applicable only if component exists (e.g., Expansion Joints)

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## 2.3 INSPECTION OF CRITICAL ELEMENTS

### Critical Elements

Structures containing Critical Elements shall be identified to ensure that inspection and assessment activities are undertaken with explicit consideration of the role these elements play in maintaining structural safety.

A Critical Element is an element whose failure would be expected to result in collapse or in a significant loss of load carrying capacity, stability, or serviceability of the structure.

Identification of Critical Elements is generally based on an evaluation of the redundancy of the load paths associated with the loads the element is required to resist. Where only one or two effective load paths are present, the element shall be considered critical. Examples of elements typically associated with non-redundant, or limited-redundancy load paths include:

- Top and bottom chords of truss bridges
- Main cables or hangers in suspension bridges
- Stay cables in cable-stayed bridges
- Arch ribs in arch bridges
- Primary load-carrying members in tied-arch bridges

Where an element participates in multiple load paths, engineering judgment and, where appropriate, structural analysis may be required to determine whether the element is critical. For example, in bridges with three lines of girders, individual girders may still be considered critical if the failure of one girder would result in unacceptable redistribution of forces, loss of stability, or exceedance of remaining member capacities.

An element may be critical based on the deterioration state, including:

- Loss of section or stiffness significantly reduces redundancy
- Remaining elements cannot safely carry redistributed loads

### Non-Critical Elements

A **Non-Critical element** is an element for which sufficient redundancy exists such that its failure would not be expected to result in collapse or a significant loss of load-carrying capacity, stability, or serviceability of the structure.

Load-path redundancy may be provided through **external redundancy**, **internal redundancy**, or a combination of both.

External redundancy exists where multiple discrete elements perform a similar structural function. Examples include multiple posts supporting a traffic barrier or a slab-on-girder bridge with four or more lines of girders or a pier cap supported by 4 or more pier columns, where load effects can be redistributed without compromising overall structural integrity. In such cases, individual girders or pier columns are generally not considered critical elements.

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Internal redundancy exists within a single structural element through the presence of multiple load-carrying components. For example, a concrete barrier wall reinforced with regularly spaced reinforcing bars exhibits internal redundancy, such that the failure of an individual reinforcing bar would not significantly affect the performance of the element or the bridge.

Engineering judgment should be applied to confirm that adequate redundancy and load redistribution capacity exist under the governing load cases and deterioration scenarios.

### 2.4 ELEMENT QUANTITY CALCULATIONS

As described earlier, this version of the Ontario Structure Inspection Manual is based on the “severity and extent” philosophy. To estimate rehabilitation needs, quantities of material defects in each Condition State must be recorded for each element. To determine the most suitable rehabilitation option, the recorded defect quantity must be compared to the overall quantity for that element. The Structure Rehabilitation Manual describes how to select the appropriate rehabilitation option based on the extent of material defects.

Tables in Section 2.4.1 describe how to calculate dimensions (length, width, height) and quantities for the various types of elements. In general, dimensions can be obtained from structural drawings, however, these values should be verified in the field (e.g., curb height may have been reduced after a resurfacing operation). It should be noted that the quantity calculation is approximate in some cases (e.g., surface area of a girder), but is accurate enough to be used in estimating rehabilitation needs. In general, quantities are calculated for one element (e.g., girder) and then the Total Quantity is calculated by multiplying the quantity by the number of that type of element (Count). The default units are m<sup>2</sup> for most elements.

To simplify the inspection process, the parts of the structure that are likely to be in similar condition are grouped together. This is accomplished by using “sub-elements”, as described in Part 2, Section 2.2. When sub-elements are used, element quantities shall be calculated for each sub-element, as described in Table 2.2.1(Note f) and Table 2.2.2 and Figure 2.4.2.1 to Figure 2.4.2.4.

For elements that are partially buried, quantities should be calculated for the part of the element that is visible above the ground (e.g., pile bents). For all other elements, the quantity shall be based on the total area of the element as shown on the plans. (e.g., ballast wall). When inspecting an element that is partially hidden (e.g., ballast wall), the quantity of material defects should be estimated based on the portion that is visible. For example, a ballast wall at an expansion joint location may show signs of severe defects if the expansion joint has been leaking. If the visible part of the wall is in “Poor” Condition, the inspector can probably assume that the remainder of the wall is in similar condition.

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**2.4.1 Calculation Tables for Element Dimensions and Quantities****2.4.1.1 Element Group: Abutments****Table 2.4.1 Element Group: Abutments**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Abutment Walls <sup>a</sup>		N/A	Avg. width	Avg. top of brg. seat el. - avg. ground el. + brg. seat width + visible footing	# of abutments	Count x width x height
Ballast walls <sup>b</sup> (w/o joints)		N/A	Avg. width	Avg. deck soffit el. - avg. brg. seat el.	# of walls	Count x width x height
Ballast walls <sup>b</sup> (w/ joints)		N/A	Avg. width	Top of deck el. - avg. brg. seat el.	# of walls	Count x width x height
Bearings		N/A	N/A	N/A	# of abutment bearings	Count (Each)
Wingwalls		Avg. length from $\phi$ brg. to end	N/A	Avg. visible height	# of wingwalls	Count x length x height

Notes: a) Includes bearing seat width and top of footing (if visible). For abutments with timber piles, use 2 locations: "Pile" = pile area ( $\pi$ DL): "Cap" = pile cap area  
b) Quantity includes entire ballast wall even if some areas are not visible due to diaphragms

**2.4.1.2 Element Group: Accessories (Attachments and Signs)****Table 2.4.2 Element Group: Accessories (Attachments and Signs)**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Bridge Mounted Sign Supports		N/A	N/A	N/A	# of Accessories	Count (Each)
Electrical		N/A	N/A	N/A	# of Accessories	Count (Each)
Noise Barriers		Avg. length including approach	N/A	Height	# walls (typ. 2)	Count x length (m)
Other		N/A	N/A	N/A	# of Accessories	Count (Each)
Signs		N/A	N/A	N/A	# of Accessories	Count (Each)
Utilities		N/A	N/A	N/A	# of Accessories	Count (Each)

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**2.4.1.3 Element Group: Approaches****Table 2.4.3 Element Group: Approaches**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Approach slabs		Approach slab length	curb to curb width	Thickness	# of approaches	Count x width x length
Barrier <sup>a</sup>		Length of Barrier			# of approaches	Count x length
Curb and gutters		Avg. length of approach slab	N/A	Min. height of curb	# of curbs	Count x length
Drainage System <sup>b</sup>		N/A	N/A	N/A	N/A	Count
Sidewalk/Curb		Avg. length of approach slab	Avg. width of sidewalk	Min. height of sidewalk curb	# of sidewalks	Count x length x (width + height)
Wearing surface <sup>c</sup>		Approach slab length	Curb to curb width	Thickness	# of approaches	Count x width x length

- NOTES:
- a) Optional element. Not required for MTO use.
  - b) General drainage at each corner of the bridge.
  - c) For culverts, wearing surface above culvert should be covered under Approaches element, where the width would be the exterior width of the culvert.

**2.4.1.4 Element Group: Barriers****Table 2.4.4 Element Group: Barriers**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Barrier/Parapet Walls <sup>a</sup>	Interior	Length (includes approaches)	Top thickness	Barrier height	# of sides	length x (height + top width) x count
Barrier/Parapet Walls <sup>a</sup>	Exterior	Total length to end of approaches for one side	N/A	Barrier height	# of sides	length x height x count
Hand Railings <sup>b</sup>		Length of railing(s) on barrier	N/A	N/A	# of sides (s) # of rails (r)	count (s) x count (r) x length (m)
Posts <sup>c</sup>		Longitudinal length of post	Transverse width of post	Height of posts	# of posts	Count (Each)
Railing Systems <sup>d</sup>		length of 1 steel panel	N/A	Height of barrier	# of panels	length x count (m)

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- NOTES:
- a) Sub-elements must be used as interior and exterior of barrier/parapet walls must be rated separately. Interior of wall quantity includes barrier top. This element is also used for concrete end posts on open railings – interior/exterior not required.
  - b) This element is to be used for single or multiple-tube railings on top of barrier/parapet walls.
  - c) This element is to be used for the post component of open type railing systems (Posts of Wood, Steel, Concrete, etc.).
  - d) This element is to be used for open type railing systems (steel railing, flex beam, etc.).

### 2.4.1.5 Element Group: Beams / Main Longitudinal Elements (MLE's)

Table 2.4.5 Element Group: Beams / Main Longitudinal Elements (MLE's)

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Diaphragms <sup>a</sup> Concrete		girder spacing	Avg. flange width	Section depth	# of diaphragms	length x count x (height x 2 + width)
Diaphragms <sup>a</sup> Cross or "K" braces		total length of members	Avg. flange width	Section depth	# of segments	Count (Each)
Diaphragms <sup>b</sup> Concrete	End	girder spacing	Avg. flange width	Section depth	# of diaphragms	length x count x (height x 2 + width)
Diaphragms <sup>b</sup> Cross or "K" braces	End	total length of members	Avg. flange width	Section depth	# of segments	Count (Each)
Diaphragms <sup>c</sup> Concrete	Intermediate	girder spacing	Avg. flange width	Section depth	# of diaphragms	length x count x (width + 2xheight)
Diaphragms <sup>c</sup> Cross or "K" braces	Intermediate	total length of members	Avg. flange width	Section depth	# of segments	Count (Each)
Floor beams <sup>a</sup>		curb to curb width	Avg. flange width	Section depth	# of beams	length x count x (height x 2 + width x 3)
Floor beams <sup>d</sup>	End	curb to curb width	Avg. flange width	Section depth	# of beams	length x count x (height x 2 + width x 3)
Floor beams <sup>e</sup>	Intermediate	curb to curb width	Avg. flange width	Section depth	# of beams	length x count x (2xheight + 3xwidth)
I-Girders <sup>a</sup>		total spans + overhangs <sup>3</sup>	Avg. flange width	Girder depth	# of lines	length x count x (2xheight + 3xwidth)
Box Girders <sup>a</sup>		total spans + overhangs <sup>3</sup>	Bottom flange width	Girder depth	# of lines	length x count x (2xheight + width)
I-Girders <sup>f</sup>	End	2m per Beam end. (opt. 1-3m)	Avg. flange width	Girder depth	# of lines	length x count x (height x 2 + width x 3)
Box Girders <sup>f</sup>	End	2m per Beam end. (opt. 1-3m)	Bottom flange width	Girder depth	# of lines	length x count x (height x 2 + width)
I-Girders <sup>g</sup>	Middle	Sum of span lengths + sum of overhangs – sum of "Ends"	Avg. flange width	Girder depth	# of lines	length x count x (height x 2 + width x 3)
Box Girders <sup>g</sup>	Middle	Sum of span lengths + sum of overhangs – sum of "Ends"	Bottom flange width	Girder depth	# of lines	length x count x (height x 2 + width)
Inside boxes <sup>a</sup>		total length (spans + overhangs)	bottom flange width	Girder depth	# of lines	length x count x (height x 2 + width)

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Inside boxes <sup>f</sup>	End	2m per Beam end. (opt. 1-3m)	bottom flange width	Girder depth	# of lines	length x count x (height x 2 + width)
Inside boxes <sup>g</sup>	Middle	Sum of span lengths + sum of overhangs – sum of “Ends”	bottom flange width	Girder depth	# of lines	length x count x (height x 2 + width)
Stringers <sup>a</sup>		floor beam spacing	Avg. flange width	Stringer depth	# of stringers	Count (Each)
Stringers <sup>h</sup>	<i>(For Modular Bridges)</i>	Length of stringer sets	Spacing of stringer sets	Stringer depth	# stringers wide x # stringers long	Count (Each)
Stringers <sup>i</sup>	End	floor beam spacing	Avg. flange width	Stringer depth	# of stringers	Count (Each)
Stringers <sup>j</sup>	Intermediate	floor beam spacing	Avg. flange width	Depth	# of stringers	Count (Each)

- NOTES:
- For all Element on bridges that do not have expansion joints. See Figures 2.4.2.1 (a), (b) and (c)
  - Diaphragms at support locations with expansion joints (piers, abutments), if similar type. End sub-elements required (see Figure 2.4.2.1 (b)).
  - All diaphragms in the span(s).
  - End floor beams at expansion joint locations (see Figure 2.4.2.1 (c)).
  - Intermediate floor beams (see Figure 2.4.2.1 (c)).
  - For decks with expansion joints.
  - To be used in areas away from expansion joints in conjunction with the “end” element (see Figure 2.4.2.1 (a))
  - Stringer sets often span over a transom. Ramp at bridge ends is an approach slab, not a stringer.
  - Stringers in end panel at exp. joint locations (see Figure 2.4.2.1 (c)).
  - Stringers in intermediate panels.

### 2.4.1.6 Element Group: Bracings

**Table 2.4.6 Element Group: Bracings**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity
Bracing <sup>a</sup>		Avg. length of 1 bracing member	N/A	N/A	# of bracing members	Count (Each)
Bracing <sup>b</sup>	End	Avg. length of 1 bracing member	N/A	N/A	# of bracing members	Count (Each)
Bracing <sup>c</sup>	Intermediate	Avg. length of 1 bracing member	N/A	N/A	# of bracing members	Count (Each)

- NOTES:
- All Bracings – includes bracing between trusses and lateral bracing between floor system in horizontal plane. Vertical plane is considered a diaphragm element (see Figure 2.4.2.1 (b)).
  - Bracings in end panel (see Figure 2.4.2.1 (c)).
  - Bracings in intermediate panel (see Figure 2.4.2.1 (c)).

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**2.4.1.7 Element Group: Coatings****Table 2.4.7 Element Group: Coatings**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Barrier Systems / Hand Railings <sup>a</sup>		N/A	N/A	N/A	N/A	Use Area of corresponding element
Structural Steel <sup>b</sup>		N/A	N/A	N/A	N/A	Use Area of corresponding element such as girder, floor beams etc.
Structural Steel <sup>c</sup>	End	N/A	N/A	N/A	N/A	Use Area of corresponding sub-element such as end of girder, end floor beams etc.
Structural Steel <sup>d</sup>	Middle	N/A	N/A	N/A	N/A	Use Area of corresponding sub-element such as middle of girder, end floor beams etc.

- NOTES:
- a) If the element units are not sq. m, obtain appropriate area.
  - b) For all structural steel.
  - c) To be used if the corresponding element used “End” elements.
  - d) To be used if the corresponding element used “Middle” elements.

**2.4.1.8 Element Group: Culverts****Table 2.4.8 Element Group: Culverts**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Barrels <sup>a</sup>		Culvert length	Avg. cell width	Height of cell	# of cells	Count x surface area of one cell
Inlet Components <sup>b</sup>		N/A	N/A	N/A	1	Area of all inlet components
Outlet Components <sup>b</sup>		N/A	N/A	N/A	1	Area of all outlet components

- NOTES:
- a) Interior surface area includes soffit, walls, and bottom slab of culvert if present and not buried.
  - b) Includes all components (head walls, cut-off walls, aprons, etc.).

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**2.4.1.9 Element Group: Decks****Table 2.4.9 Element Group: Decks**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Deck Top <sup>a</sup>		sum of (span lengths + overhangs)	overall width (out-to-out)	Deck thickness	N/A	Length x width
Drainage System <sup>b</sup>		N/A	N/A	N/A	N/A	Count (Each)
Soffit – Inside Boxes <sup>c</sup>		sum of (span lengths + overhangs)	Sum of distance between top flanges inside of boxes (steel or concrete)	N/A	N/A	Length x width
Soffit – Inside Boxes <sup>d</sup>	End	2m per Beam end. (opt. 1-3m)	Sum of distance between top flanges of boxes (steel or concrete)	N/A	N/A	Length x width
Soffit – Inside Boxes <sup>e</sup>	Middle	Sum of (span lengths + overhangs - “Ends”)	Sum of distance between top flanges of boxes (steel or concrete)	N/A	N/A	Length x width

## NOTES:

- a) See Figure 2.4.2.1 (b).  
b) Includes all components such as drains, drainpipes, connecting pipes, etc. Can also be per side of the bridge.  
c) The entire soffit length inside the boxes. To be used for decks without expansion joints (see Figure 2.4.2.2 (c)).  
d) For decks with expansion joints (see Figure 2.4.2.2 (c)).  
e) To be used in areas away from expansion joints in conjunction with the “end” element (see Figure 2.4.2.2 (c)).

**2.4.1.10 Element Group: Decks (Thick Slab)****Table 2.4.10 Element Group: Decks (Thick Slab)**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Soffit – Thick Slab (PT Decks and Rigid Frames) <sup>a</sup>	End	2m per Beam end. (opt. 1-3m)	Overall width + fascias	N/A	N/A	Length x width
Soffit – Thick Slab (PT Decks and Rigid Frames) <sup>b</sup>	Exterior	Sum of (span lengths + overhangs - “Ends”)	Fascias + cantilevers	N/A	N/A	Length x width

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Soffit – Thick Slab (PT Decks and Rigid Frames) <sup>c</sup>	Interior	Sum of (span lengths + overhangs - “Ends”)	Overall width – cantilevers	N/A	N/A	Length x width
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- NOTES:
- a) For decks with expansion joints
  - b) For Rigid Frames, span lengths are from faces of abutments and piers. The cantilever is assumed to be 1 m as shown in Figure 2.4.2.4. When End elements are used, the length will be reduced by the sum of the End elements (see Figure 2.4.2.2 (c)).
  - c) For Rigid Frames, span lengths are from faces of abutments and piers. When End elements are used, the length will be reduced by the sum of the End elements (see Figure 2.4.2.2 (c)).

### 2.4.1.11 Element Group: Deck (Thin Slab)

**Table 2.4.11 Element Group: Deck (Thin Slab)**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Soffit – Thin Slab <sup>a</sup> Box or I-Girders	End	2m per Beam end (opt. 1-3m)	fascias + exterior cantilevers to flanges + sum of distances between flanges (for boxes use outside of box top flanges only)	N/A	N/A	Length x width
Soffit – Thin Slab <sup>b</sup> Box or I-Girders	Exterior	Sum of (span lengths + overhangs - “Ends”)	fascias + exterior cantilevers to flanges	N/A	N/A	Length x width
Soffit – Thin Slab <sup>c</sup> Box or I-Girders	Interior	Sum of (span lengths + overhangs - “Ends”)	sum of distances between flanges (for boxes use outside of box top flanges only)	N/A	N/A	Length x width
Wearing Surface		Sum of (span lengths + overhangs)	Roadway width (curb to curb)	Thickness	N/A	Length x width

- NOTES:
- a) For decks with expansion joints.
  - b) When End elements are used, the length will be reduced by the sum of the End elements.

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**2.4.1.12 Element Group: Embankments and Streams****Table 2.4.12 Element Group: Embankments and Streams**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Embankments <sup>a</sup>		N/A	N/A	N/A	N/A	Units are Each
Slope Protection <sup>b</sup>		N/A	N/A	N/A	N/A	Units are Each
Streams and Waterways		N/A	N/A	N/A	N/A	Units are All

NOTES: a) A typical abutment has 3 embankments (1 at front face and 2 side slopes).  
b) A typical abutment has 3 slopes (1 at front face and 2 side slopes).

**2.4.1.13 Element Group: Foundations****Table 2.4.13 Element Group: Foundations**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity
Foundation (below ground level) <sup>a</sup>		N/A	N/A	N/A	N/A	N/A

NOTES: a) Foundation is considered to be anything below ground. This element is rated for performance only and not material condition.  
If top of footing is visible, it should be rated under the Retaining Wall, Abutment Wall, or Pier Shaft element.

**2.4.1.14 Element Group: Joints****Table 2.4.14 Element Group: Joints**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Armouring / retaining devices <sup>a</sup>		Overall width (out-to-out) for 1 armouring	N/A	N/A	# of armourings	Count x length (m)
Concrete end dams		Curb to curb width	width of one dam	N/A	# of end dams	Count x length x width
Seals / sealants		Overall bridge width	N/A	N/A	# of seals	Count (Each)

NOTES: a) For multi-seal joints, the total length shall include the armouring and the separator beams.

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## 2.4.1.15 Element Group: Piers

Table 2.4.15 Element Group: Piers

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Bearings		N/A	N/A	N/A	Total # of bearings at piers	Count (Each)
Caps <sup>a</sup>		Thickness or length of caps parallel to length of bridge	width of cap	Depth or height of cap	# of caps	Count x 2x[(width x height) + (length x height) + (length x width)]
Shafts/Columns/Pile Bents <sup>b</sup>		<p><u>For Rectangular Shaft or Column:</u> Thickness parallel to bridge length</p> <p><u>For Round Columns, Pipe Piles or Timber Piles:</u> Diameter</p> <p><u>For H-Pile Bents:</u> web heights</p>	<p><u>For rectangular Shaft or Column:</u> avg. width of shaft or column</p> <p><u>For Round Columns, Pipe Piles or Timber Piles:</u> Diameter</p> <p><u>For H-Piles:</u> flange width</p>	Bearing seat elevation or elevation at bottom of pier cap - top of ground elevation (if under water use stream bed elevation) + bearing seat width + visible part of footing (footing may also be treated as a separate “cap” element)	# of shafts or # of columns or # of piles	<p><u>For Rectangular Shafts or Columns:</u> 2 x (length + width) x height x count</p> <p><u>For Round Columns, Pipe Piles or Timber Piles:</u> <math>\pi</math> x width x height x count</p> <p><u>For H Piles:</u> Count x height x (2xlength + 4xwidth)</p>

- NOTES:
- The cap beams for timber abutments with wooden piles can be recorded as Pier Caps.
  - Similar shapes should be combined as an element. Includes bearing seat width and top of footing (if visible) – may not be applicable for all situations.

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**2.4.1.16 Element Group: Retaining Walls****Table 2.4.16 Element Group: Retaining Walls**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Barrier Systems on Walls <sup>a</sup>	Interior	Total length	Thickness at top	Barrier height	# of sides	Length x (height + top width) x count
Barrier Systems on Walls <sup>a</sup>	Exterior	Total length	N/A	Barrier height	# of sides	Count x length x height
Walls		Avg. length of wall	N/A	Avg. height of wall	# of walls	Count x length x height

NOTES: a) Sub-elements must be used as interior and exterior of barrier/parapet walls must be rated separately. Interior of wall quantity includes barrier top.

**2.4.1.17 Element Group: Sidewalks / Curbs****Table 2.4.17 Element Group: Sidewalks / Curbs**

Element Name	Sub-element	Length (m)	Width (m)	Height (m)	Count	Quantity (m <sup>2</sup> )
Curbs <sup>a</sup>		Total length on bridge	Avg. width of all curbs	Height of vertical face	# of curbs	Count x length x (width + height)
Sidewalks and medians <sup>a, b</sup>		Total length on bridge	Avg. width of all sidewalks and medians	Height of vertical face	# of sidewalks / medians	Count x length x (width + height)

NOTES: a) See Figure 2.4.2.3 for definition of sidewalk / median and curb.  
b) It is acceptable to record the entire length of sidewalk/curb (including approach portion) as one element and omit the sidewalk/curb on approach element.

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**2.4.1.18 Element Group: Trusses / Arches****Table 2.4.18 Element Group: Trusses / Arches**

<b>Element Name</b>	<b>Sub-element</b>	<b>Length (m)</b>	<b>Width (m)</b>	<b>Height (m)</b>	<b>Count</b>	<b>Quantity (m<sup>2</sup>)</b>
Bottom Chords I-Sections		total length of bottom chord (all panels)	Avg. flange width	Section Depth	# of chords/sides	Count x length x (2xheight + 4xwidth)
Bottom Chords T or L Sections		total length of bottom chord (all panels)	Avg. flange width	Section Depth	# of chords/sides	Count x length x (2xheight + 2xwidth)
Connections <sup>a</sup>		N/A	N/A	N/A	# of connections	Count (Each)
Top chords I-Sections		total length of top chord (all panels)	Avg. flange width	Section Depth	# of chords/sides	Count x length x (2xheight + 4xwidth)
Top chords T or L Sections		total length of top chord (all panels)	Avg. flange width	Section Depth	# of chords/sides	Count x length x (2xheight + 2xwidth)
Verticals / Diagonals I-Sections		Avg. length of diagonals	Avg. flange width	Section Depth	# of verticals / diagonals for all sides	Count x length x (2xheight + 4xwidth)
Verticals / Diagonals T or L Sections		Avg. length of diagonals	Avg. flange width	Section Depth	# of verticals / diagonals for all sides	Count x length x (2xheight + 2xwidth)

NOTES: a) Main truss connections. *For Modular Truss Bridges, a separate connection occurs at each main pin location for each top and bottom chord and chord reinforcement. Other less significant connections (such as transom clamps, raker pins, bracing frame bolts) should be inspected and recorded with the actual elements.*

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2.4.2 Element Quantity Figures

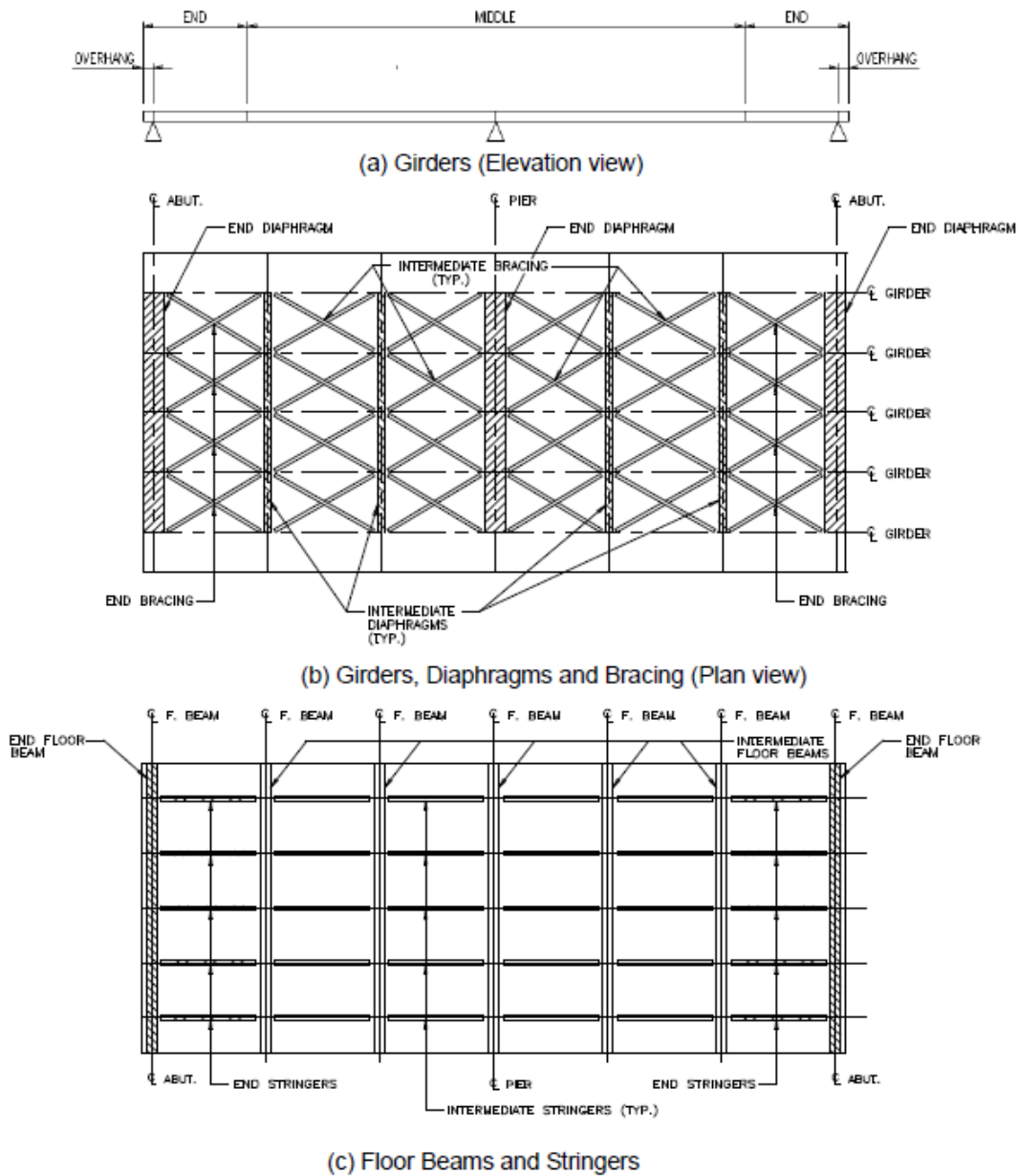
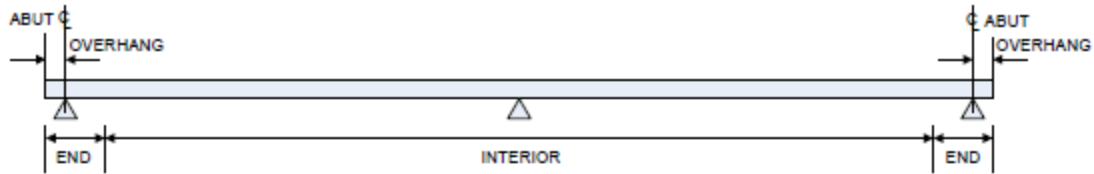
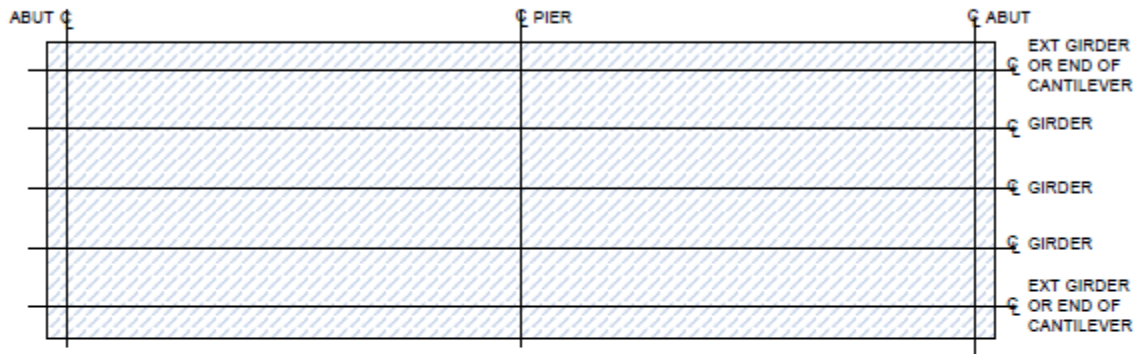


Figure 2.4.2.1 Structural Steel Definitions.

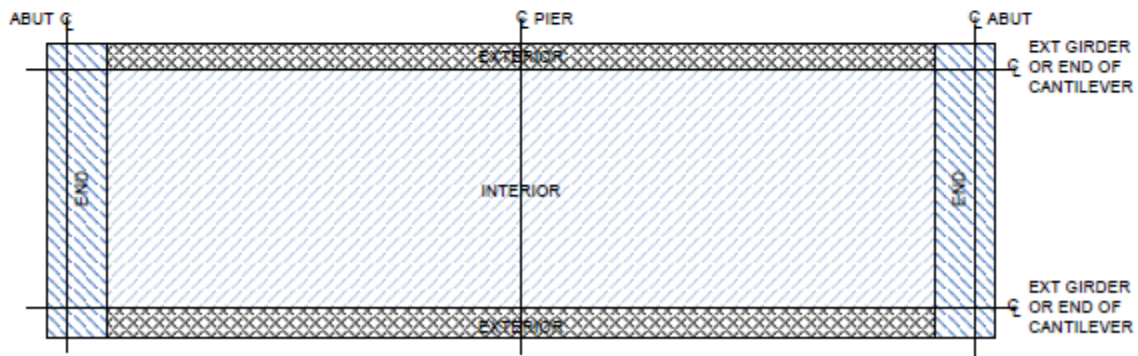
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(a) Deck (Elevation view)



(b) Deck Top (no sub-element)



(c) Deck Soffit (with possible sub-elements as shown)

Figure 2.4.2.2 Deck Definitions.

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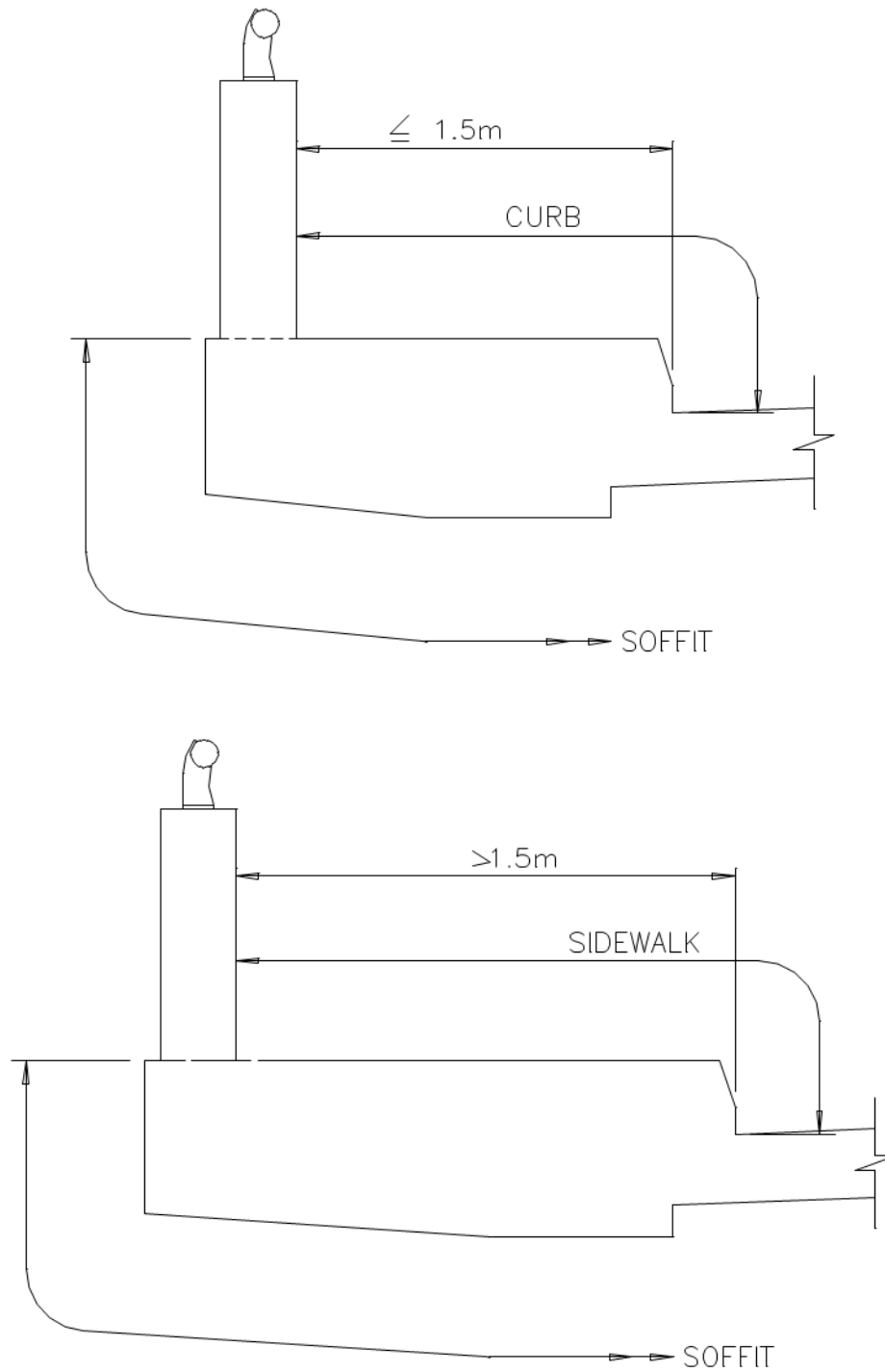


Figure 2.4.2.3 Curb and Sidewalk Definitions.

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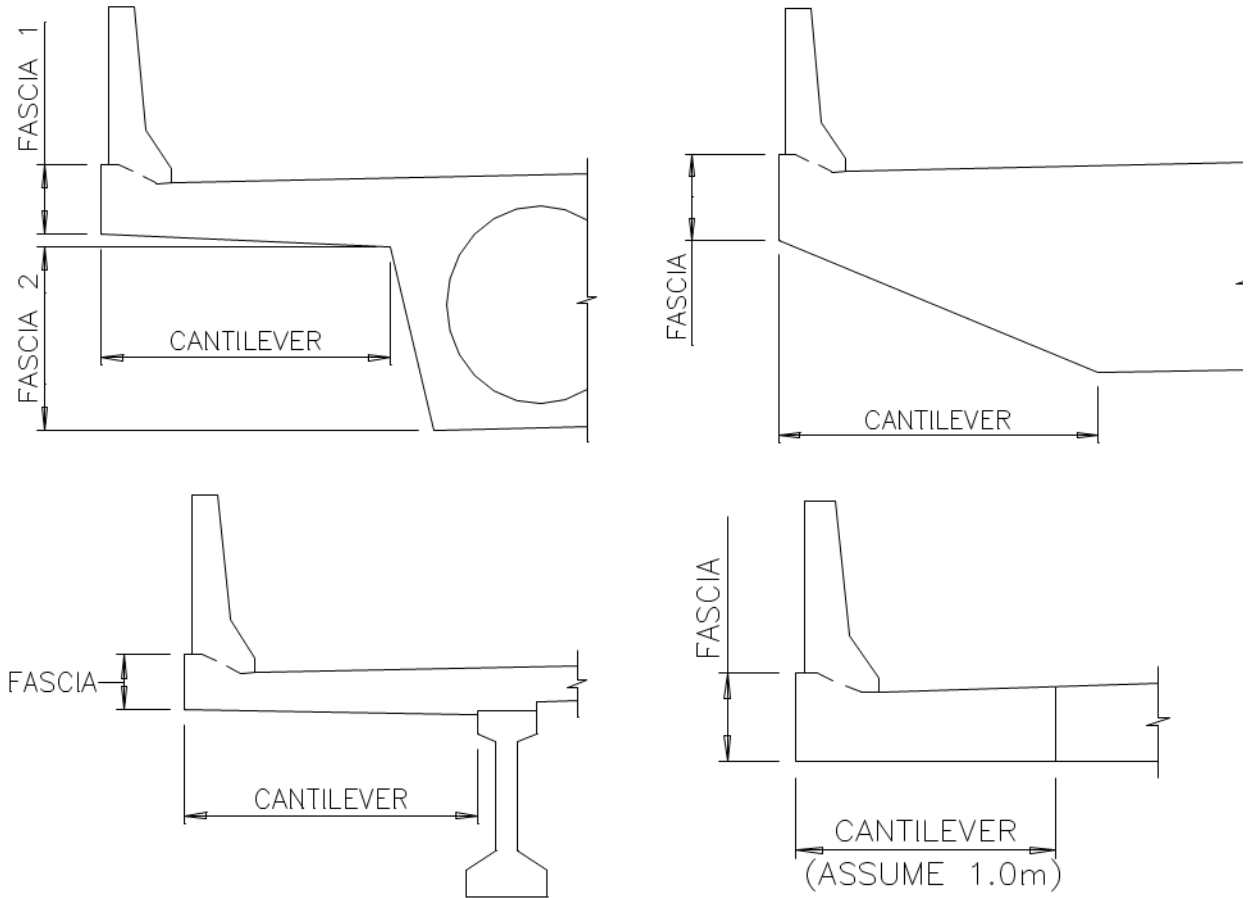


Figure 2.4.2.4 Cantilever Definitions.

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## 2.5 MATERIAL CONDITION STATES

### 2.5.1 General Description of Condition States

In general, Material Condition States are used to categorize the condition of an element based on the severity of material defects.

Four Material Condition States have been defined for bridge elements, namely, Excellent, Good, Fair and Poor. The condition of bridge elements is defined to be in any one or more of these Condition States. At any given time, areas within a bridge element may be in different Condition States, or the whole of the element may be in the same Condition State. For each bridge element, the inspector assesses and records the amount (area, length, or unit, as appropriate) of the element in each of the four Condition States. This assessment is based predominately on visual observations, however, some non-destructive testing, such as hammer tapping of concrete for delamination, will be required to determine or verify areas in poor condition. **Where an area in poor condition is noted, the area is to be measured (if practicable) or estimated as a last resort.**

In some cases, an exceptionally poor localized zone in a critical element may render the entire element ineffective. For such cases, the element can be considered to be 100% Poor and immediate action must be taken. This includes notifying the owner to initiate temporary repairs and a strength evaluation. Examples of this include:

- A truss member where perforation corrosion at one location (i.e., near a gusset or passing through a sidewalk) will result in the length between panel points being rated as Poor.
- A corrugated steel pipe culvert where perforation corrosion at one location (i.e., bottom or waterline) will result in the entire circumferential band being rated as Poor, for the length of the perforation.
- A timber pile where damage (decay, ice damage, etc.) that greatly reduces the capacity, but occurs in a small zone (i.e., the waterline) will result in that pile being rated as Poor.

### 2.5.2 Quantifying The Condition States

The importance of recording quantities of defects, by measurement (i.e. m, m<sup>2</sup>, each, or all) cannot be over-emphasized. Using rough percentages without some sort of verification will usually lead to a grossly inaccurate estimation of rehabilitation needs. This is especially true in the “Poor” Condition State. Although the extent of defects is still based on visual observations, studies have shown that the recording of actual quantities (square metre or metre) leads to a better estimation of rehabilitation needs.

There are four basic units that are used to describe the material condition of various elements (See Table 2.2.1):

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- **SQUARE METRE (Area):** For many elements, the condition states will be recorded as an area measurement, m<sup>2</sup>. For example, a deck element of area 1000 m<sup>2</sup> may have 100 m<sup>2</sup> in excellent condition, 700 m<sup>2</sup> in good condition, 100 m<sup>2</sup> in fair condition and 100 m<sup>2</sup> in poor condition. These quantities should be recorded in whole numbers.
- **LINEAR METRE (Length):** For some elements, such as the expansion joint armouring, the data is recorded by linear metre. For example, an expansion joint armouring of 10 m length may have 0 metres in excellent condition, 3 metres in good condition, 2 metres in fair condition, and 5 metres in poor condition. These quantities should be recorded in whole numbers.
- **EACH:** For some elements, such as bearings, the unit is “each”. For example, a bridge with 10 bearings may have 5 bearings in excellent condition, 3 bearings good condition, 1 bearing in fair condition and 1 bearing in poor condition.
- **ALL:** For some elements, the entire element is placed completely into one condition state as described in the appropriate condition state (e.g., streams and waterways).

The Condition States in Sections 2.5.4 –Section 2.5.20 have been created for each material type (e.g., steel, concrete) and, where required, for specialized elements (e.g., bearings, expansion joint seals, etc.). The Condition State an element is in is defined by the severity of the defect(s) that exist in that element. All material defects are defined in Section 2.5 of this manual and examples can be found in Appendix A of Part 2. In general, the severity of a defect is defined by the terms “Light, Medium, and Severe”. The definitions of these severity terms are also contained in Part 2, Section 2.5 for each type of defect. Appendix B of Part 2 contains Tables with an amalgamation of the information in Part 2, Section 2.5 and this section.

**As a rule, the following philosophy is used for most condition state tables:**

- (i) Excellent:
  - This refers to an element (or part of an element) that is in “new” (as constructed) condition
  - No visible deterioration type defects are present and remedial action is not required.
  - Minor construction defects do not count as visible deterioration type defects.
  - Examples:
    - “Bug holes” in concrete barrier walls
    - Well-formed patina in atmospheric corrosion resistant (ACR) steel girders
- (ii) Good:
  - This refers to an element (or part of an element) where the first sign of “Light” (minor) defects are visible. This usually occurs after the structure has been in service for a number of years. These types of defects would not normally trigger any remedial action since the overall performance of the element is not affected.
  - Examples:
    - Light corrosion (no section loss)
    - Light scaling
    - Light decay in wood
- (iii) Fair:

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- This refers to an element (or part of an element) where medium defects are visible. These types of defects may trigger a “preventative maintenance” type of remedial action (e.g., sealing, coating, etc.) where it is economical to do so.
  - Examples:
    - Medium corrosion (up to 10% section loss)
    - Medium scaling in concrete
- (iv) Poor:
- This refers to an element (or part of an element) where severe and very severe defects are visible. In concrete, any type of spalling or delamination would be considered “poor” since these defects usually indicate more serious underlying problems in the material (e.g., corroding reinforcing steel). These types of defects would normally trigger rehabilitation or replacement if the extent and location affect the overall performance of that element.
  - Examples:
    - Severe corrosion (greater than 10% section loss)
    - Spalling, delaminations, etc.

For a typical inspection, the “Poor” areas of each element are identified first. Generally, each area of “Poor” also has an area in the “Fair” Condition State surrounding it. This area is usually, as a minimum, equal to the area of “Poor” for small quantities of “Poor”, while for larger quantities of “Poor” a smaller percentage of the area can be used. There are also separate areas in the “Fair” Condition State that are to be included. The remainder of the areas are in either “Good” or “Excellent” Condition.

### 2.5.3 Transitions Through the Condition States

For most elements, a general progression through all the condition states occurs over time as the structure ages and deteriorates. This section will describe how to transition elements through the various condition states as they age over time. The age and the exposure environment typically play a significant role in how quickly the elements transition over time.

#### 2.5.3.1 Transitioning Elements (“Excellent” to “Good”)

Elements of ‘recently’ constructed or rehabilitated structures transition through the condition states of Excellent to Good, over time, as the structure ages. The difference between the “Excellent” and “Good” condition states is not always obvious from a distance; however, minor defects can be detected upon close visual inspection of elements more than 5 years old (depending on the exposure environment). As elements begin to age, to avoid drastic changes in condition quantities for the total structural inventory, a systematic transition of an elements condition from excellent to good is desired.

To support this controlled transition, inspectors should use the following guidelines to supplement visual inspection data and determine when an element should progress from “Excellent” to “Good”. Unless a new or replaced element has visible defects, it should remain in Excellent condition until the expiration of that elements “Excellent Period”. After expiration of the Excellent Period, all elements should take 5 years (for bridges) or 10 years (for culverts) to

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transition from “Excellent” to “Good”. The environmental exposure determines the length of the Excellent Period and the years over which the transition from Excellent to Good should occur is given in Table 2.5.3.2.5.1 below. During the transition period, 20% (bridges) or 10% (culverts) of the elements total quantity should be changed from Excellent to Good each year.

**Table 2.5.3.2.5.1 Guidelines for the Controlled Transition from "Excellent" to "Good"**

Environmental Exposure	Excellent Period	Transition Period	
	Condition remains Excellent	Bridge Transition E to G	Culvert Transition E to G
Harsh	Years 0-5	Years 6-10	Years 6-15
Moderate	Years 0-15	Years 16-20	Years 16-25
Benign	Years 0-25	Years 26-30	Years 26-35

- During the transition period for bridges, 20% of a bridge element’s original total quantity should be converted from excellent to good condition annually. (i.e. cumulatively Yr1 20%, Yr2 40%, Yr3 60%, Yr4 80% and Yr5 100%).
- During the transition period for culverts, 10% of a culvert’s element’s original total quantity should be converted from excellent to good condition annually.
- If an inspector sees defects prior to the recommended transition period they shall record the observed defect quantities accordingly – as observed (See Transition Example 2 below).
- During the transition period, the inspector shall record the observed quantities as seen but, the quantity of good shall not be less than what the required transition amount is as described in this section. (See Transition Example 3 below).
- If the quantity of observed minor defects representing a good condition state is greater than the quantity of good recommended by the transitioning guidelines, the quantity based on observed defects shall be used.
- If the inspector finds that there are quantities of fair or poor, then this amount should be subtracted from the Excellent quantities after it has already been adjusted by the recommended transition amount. Examples of various transition situations can be found below:

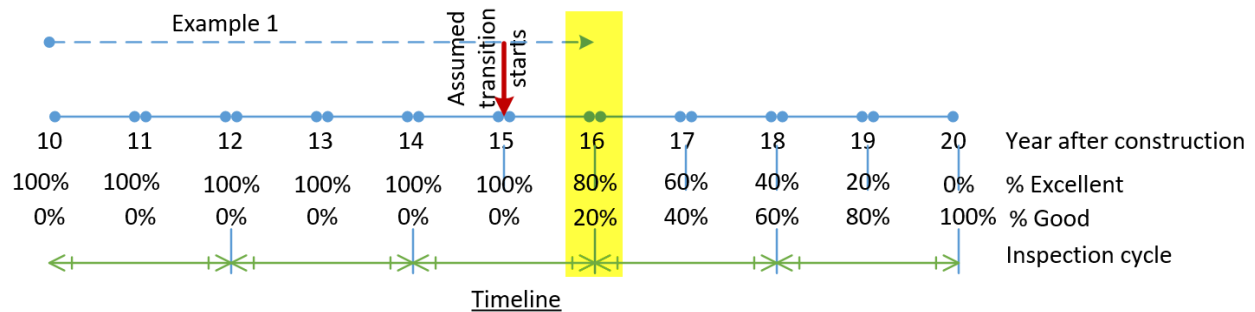
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**Transition Example 1:**

A bridge is 16 years old at the time of inspection and the Exterior Soffit is being inspected (Moderate environmental exposure). Based on the guidelines the element should start transitioning from “Excellent” to “Good” at year 16 and should finish transitioning in year 20. The previous condition state was 100% Excellent with no defects found. Based on the timeline shown in Figure 2.5.3.1 below, at year 16, 20% of the total quantity should be placed in the Good condition state, with the remainder in “Excellent”.



**Figure 2.5.3.1 Example 1 Timeline.**

**Transition Example 2:**

The interior face of the barrier wall is being inspected in the 4<sup>th</sup> year after it has been newly constructed. Its environmental exposure is harsh, and the previous inspection recorded that 100% of the quantity was in “Excellent” condition. Based on the elements age and exposure level the transition from “Excellent” to “Good” does not need to begin; but, the inspector observes that there is some deterioration and selects to add 5% in fair condition and 5% in Good. In this case, the inspector should record their observed findings as:

- 90% - “Excellent”
- 5% - “Good”
- 5% - “Fair” (e.g., observed Medium cracks)

**Transition Example 3:**

This is a continuation of Transition Example 2. At the next inspection (Year 6) the inspector observes that there is 12% in “Fair” and 13% in “Good” and the rest is in “Excellent” condition.

Table 2.5.3.2.5.2 below shows a summary of observed findings and the recorded findings that adjust for transitioning a portion of the quantities from “Excellent” to “Good”.

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Table 2.5.3.2.5.2 Summary of Example Condition States

Example 3	Excellent (%)	Good (%)	Fair (%)
Inspection Record from Yr. 4	90	5	5
Observed Finding at Yr. 6	100-13-12 = 75	13	12
<b>Final Condition States Recorded at Yr. 6</b>	<b>100-20-12 = 68</b>	<b>20</b>	<b>12</b>

In Figure 2.5.3.2 below is a timeline showing the recommended transition quantities and timing for Example 2 and 3, prior to the observation of defects:

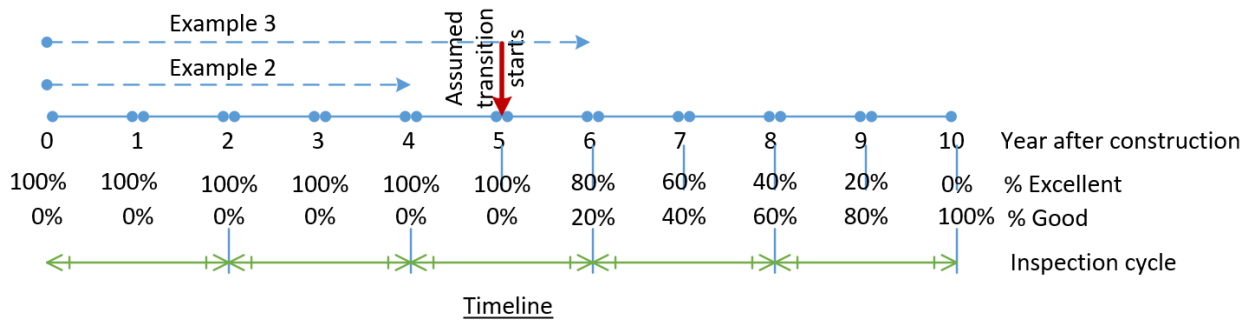


Figure 2.5.3.2 Example 2 and 3 Timeline.

2.5.3.2 Transitioning Elements to a Better Condition State (e.g. Poor to Good)

An element can also move from the “Poor” condition to being in the “Good” or “Excellent” in the following ways:

- If the element is repaired and the **repair is of a temporary nature** but does restore the element’s effectiveness (capacity), then the portion of the original element in “Poor” will remain rated as “Poor”, (e.g., a pre-stressed concrete girder is struck by a high load and repaired with concrete materials by form and pump. The repairs only reinstate some of the durability provided by the original concrete, because the original materials were in a state of compression that cannot be matched for the repair materials.). **NOTE: After permanent repairs have been made (e.g., girder replacement), the elements condition may be then rated as Excellent if warranted.**
- If the element has been repaired locally in a permanent and durable manor so that the capacity has been fully restored, the condition of the repaired area can be considered

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“Good” (the quantity of repair compared to the original area is small and recording these minor quantities as Excellent is not required). **NOTE: Inspector needs to adjust the Poor to Good.**

- If the permanent repair is to the entire element (such as a deck overlay, a complete abutment or barrier refacing, a column wrapping, or girder replacement), the element would be considered “Excellent”. **NOTE: Inspector needs to adjust Good, Fair and Poor quantities to 0% and make the Excellent quantity 100%.**

### 2.5.4 Concrete – Substructures and Superstructures

This section describes concrete material defects, followed by a summary table of defect definitions versus condition state (see Table 2.5.4. and Table 2.5.3), then followed by photos to visually show sample defects.

Concrete is used in many ways in the construction of bridges and culverts, from plain concrete, such as mass concrete in foundations to normally reinforced concrete used in most structural elements, to pre-stressed or post-tensioned concrete used in main longitudinal elements

Defects in concrete can often be related to the lack of durability of the concrete, resulting from the composition of the concrete, poor placement practices, poor Quality Control, or the aggressive environment in which it is placed. The following defects commonly occurring in concrete are described:

- Scaling
- Disintegration
- Erosion
- Corrosion of Reinforcement
- Delamination
- Spalling
- Cracking
- Alkali-Aggregate Reaction (AAR)
- Delayed Ettringite Formation (DEF)
- Surface Defects

#### 2.5.4.1 Scaling

Scaling is the local flaking, or loss of the surface portion of concrete or mortar because of the freeze-thaw deterioration. Scaling is common in non-air-entrained concrete but can also occur in air-entrained concrete in the fully saturated condition. Scaling is prone to occur in poorly finished or overworked concrete where excess fines and not enough entrained air is found near the surface. Scaling of concrete is shown in Figure 2.5.4.1.

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**Figure 2.5.4.1 Severe Scaling in a Barrier Wall**

### **2.5.4.2 Disintegration**

Disintegration is the physical deterioration or breaking down of the concrete into small fragments or particles. The deterioration usually starts in the form of scaling and, if allowed to progress beyond the level of very severe scaling is considered as disintegration. Disintegration may be caused by de-icing chemicals, sulphates, chlorides or by frost action. Disintegration of the concrete is illustrated in Figure 2.5.4.2.

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**Figure 2.5.4.2 Severe Disintegration of Concrete Culvert**

### **2.5.4.3 Erosion**

Erosion is the deterioration of concrete brought about by water-borne sand and gravel particles scrubbing against concrete surfaces. Similar, damage may be caused by flowing ice. Erosion is sometimes combined with the chemical action of air and water-borne pollutants which accelerate the breakdown of the concrete.

Erosion is generally an indication that the concrete is not durable enough for the environment in which it has been placed. Severe erosion of a concrete wingwall is shown in Figure 2.5.4.3.

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**Figure 2.5.4.3 Severe Erosion of a Concrete Wingwall**

#### **2.5.4.4 Corrosion of Reinforcement**

Corrosion is the deterioration of reinforcement by electrolysis. The alkali content in concrete protects the reinforcement from corrosion. However, when chloride ions above a certain concentration are dissolved in water and penetrate through the concrete to the reinforcement this protection breaks down and corrosion starts. In the initial stages, corrosion may appear as a rust-stain on the concrete surface. In the advanced stages, the surface concrete above the reinforcement cracks, delaminates and spalls off - exposing heavily rusted reinforcement. This process is illustrated in Figure 2.5.4.4 and Figure 2.5.4.5.