Road Structures Inspection Manual

Part 3: Condition Rating of Structure Components

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Government of South Australia
Department of Planning, Transport and Infrastructure

Road Structures Inspection Manual

Part 3: Condition Rating of Structure Components
Department of Planning, Transport and Infrastructure, South Australia

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and adjusted for South Australian conditions.

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1 CONDITION RATING OF STRUCTURE COMPONENTS

Part 2 of the Road Structures Inspection Manual (RSIM) provides information regarding defects which are applicable to a variety of materials used in structure components as well as the most common causes of structure deterioration. This Part provides guidance on the condition rating of structural components. Part 4 provides descriptions of each condition state and photographic examples of the different condition states.

DPTI uses Structures Manager - a computerised inventory system - to store structural inspection and inventory data. The value of structural inspections depends on the quality and consistency of the inspection data and how it is subsequently recorded and reported.

Inspection data is used to inform statewide maintenance, strengthening and rehabilitation programs. For this reason it is important that inspections are conducted to a consistent and repeatable standard and that data are comparable across the State regardless of who performs the inspection.

In order to ensure consistency of reporting, the RSIM includes standard descriptions for:

- Structural components
- Different levels of deterioration
- Degree of aggressiveness of the environment

Inspectors are required to make an assessment of the condition state of all structure components, and an overall assessment of the structure as a whole.

1.1 Structure Components

For ease of identification and reporting, the majority of structures and the standard components likely to be encountered are predefined and described in Appendix A.

As outlined in Part 1 Section 2.4.8.1.2 to allow for systematic inspections of structures, components have been grouped for inspection purposes. The principal inspection groups are Approach, Abutment, Span, Pier and Deck. There is an additional inspection group per structure type that includes elements that don’t necessarily fit the principal groups and elements specific to that structure type.

The inspection components can be further divided into five categories describing the material from which they are constructed. The five material types are steel, precast concrete, cast insitu concrete, timber and other. The steel grouping includes aluminium, cast and wrought iron members while the other grouping comprises brickwork, masonry, gravel, neoprene, bitumen, cork, malthoid, fibre reinforced polymer and any other material not listed.

Precast concrete members can generally be distinguished from cast insitu concrete by the smooth, uniform and dense surface and are typically whiter in colour.

The Component Schedule contained in Table B-1 of Appendix B includes a complete listing of standard components along with their corresponding units of measurement and applicable material types.

The Standard Component Matrix included in Table B-2 of Appendix B shows the association between standard components and inspection groups.

In some instances, inspectors may encounter a structure with a configuration that does not fit within the terminology described. For the designation of groups and components in such instances it is recommended that the Principal Engineer Bridge Assets be contacted to provide advice on component breakdown of the structure and other related issues.

1.2 Condition Rating of Components

This section of the manual provides guidance to inspectors on the identification of components and the quantification of the amounts of components in the various condition states using the detailed descriptions which follow. The descriptions do not cover every situation and the inspector should use their knowledge and reasoning to interpret which condition state should apply in a particular situation.

1.2.1 Condition States

In general the condition states have been developed to reflect the discernible stages of deterioration as shown in Table 1.

Condition State	Description
1	Component is in good condition with little deterioration.
2	Component shows minor deterioration with primary supporting material showing the first signs of being affected.
3	Component shows moderate deterioration with primary supporting material showing signs of being affected however not requiring intervention or preventative maintenance at this stage.
4	Component shows advancing deterioration and loss of protection to the supporting material which is showing deterioration and minor loss of section. As a result, preventative maintenance may need to be considered by the asset manager to slow the rate of deterioration or improve the component condition.
5	Component shows advanced deterioration, loss of effective section to the primary supporting material, is not performing as designed or is showing signs of distress or overstress. As a result, maintenance, repair or replacement of the component will be required to improve the condition of the component.

Table 1: Condition state descriptions

Descriptions of the five condition states for each structure component are given in Part 4 of this Manual. The condition states for each component describe possible problems for those components. They do not necessarily describe all defects which may be found. The inspector should use their expert knowledge to interpret which description best fits the particular condition state and the severity and possible consequences of the defect.

The inspector shall make an assessment of the condition of each component and the extent over which that condition applies.

In doing so, the inspector shall compare the defects observed in each component with the guidance provided in Part 4 for each standard component. These descriptions cannot possibly cover every situation and the inspector is expected to exercise judgement based

on his or her knowledge and experience and the guidelines given in Table 2 to identify the appropriate condition state(s) applicable to each component inspected.

In completing the Survey 123 mobile inspection form the inspector should rate the component according to the method of measurement described in Section 1.2.2. For any component which has a condition state rating of 4 or 5 the description should provide the location of the defect so that a person unfamiliar with the structure could be directed to the exact location. The description of the defect must be comprehensive and accurate so that a person can have a clear understanding of the description of the problem. The area/amount of the defect must be measured (in the units of measurement for that component) to enable an approximate estimate of the repair or replacement cost to be made. Photographs corresponding to the condition states described are provided in Part 4.

1.2.2 Measurement of Condition Rating

The quantity of the component in each condition state shall be determined on the basis of the total visible portion of that component; that is, the portions in each condition state (1, 2, 3, 4 and 5) must add up to the total quantity of that component observed on site. The quantity of the component in each condition state is to be input to the Survey 123 mobile inspection form. Where there is a single component to be rated (with unit of measurement each), with varying condition state over sections of the component, an estimation can be made of a portion/percentage of area of the component in different condition states. The total value in the 'quantity field' must still add up to one.

The quantity of component in each condition state shall be based on the total component that can be observed. Where it is estimated that only 25% or less of the component is visible this fact shall be recorded on the Survey 123 mobile inspection form, stating the reason why it cannot be fully observed. Such items shall still be assigned a condition state, which shall be based on the visible portion of the component.

If components are missing or cannot be observed these should be noted in the comments section of Survey 123 mobile inspection form. If a structure does not have an approach railing or structure barriers this should be noted in the comments section. In both instances, no condition rating is required.

Each component to be assessed is quantified using one of the following units of measurement:

Number of units making up the component	(each)
Length of the component	(lin m)
Area of the component	(m^2)

Table 2: Element quantity types

The unit of measurement to be used for each of the standard components and associated materials is indicated in Table B-1 of Appendix B.

In assessing the relative quantities of the component in the various condition states, the inspector should first determine the worst condition affecting the component and its extent then progress through to the best condition pertaining to that component.

Element	No of components	Condition Rating				
		1	2	3	4	5
Bearings	27 total	1	2	12	10	2

Table 3: Example condition rating summary

1.2.2.1 Components Measured on an Area (m^2) Basis

When rating components that are measured on an area (m^2) basis, certain assumptions must be made when rating areas of deteriorated concrete and estimating the affected areas.

It is possible that the damaged area is much larger than the visible cracks or spalls. For an isolated crack or spall, the damaged area is defined by a line 0.25m all around the crack or spall. If this defect is interconnected with other cracked or spalled areas then the damaged area is defined by area 0.25m around the combined defects. This also applies to the underside of bridge decks where the deck reinforcement is showing at the concrete surface but no cracking or spalling exists.

i.e.:

- for a small spall the minimum area of deterioration for the condition rating shall be $0.25m^2$
- for a crack across the deck the minimum area will be 0.5m by the width of the deck.
- for a corner bar crack in a pier wall the deteriorated area will be 0.25m (or wall thickness if less) by 0.25m on the wall face by the length of crack plus 0.25m if the crack commences at the footing or plus 0.5m if the crack is higher up the wall.

Steel, precast concrete, timber and asphalt areas rated on a square metre basis are based on the area of deterioration visible.

Where no element measurement is specified or the element measurement is equal to 1, inspectors should estimate the portion/percentage of the area of the component in the different condition states. This portion/percentage should then be input into the Survey 123 inspection form as a decimal (e.g. 50% = 0.5). In this situation, the values entered in the five condition states must add up to one for the element.

1.2.2.2 Components Measured in Linear Metres

When rating concrete components that are measured in linear metres an estimate of the length of the cracked or spalled concrete is required. A similar approach is then used to that adopted for determining the areas of defective concrete.

If one severe crack occurs through a kerb - say over the pier - and is assessed as Condition State 4 the length in that condition is 0.5m (0.25m each side of the crack). If the total length of kerb is 100m the overall assessment would be:

Element	No of	CS1	CS2	CS3	CS4	CS5
Kerb	100	99	0	0	1	0

Table 4: Example rating components on linear metres basis

Where no element measurement is specified or the element measurement is equal to 1, inspectors should estimate the portion/percentage of the area of the component in the different condition states. This portion/percentage should then be input into the Survey 123 inspection form as a decimal (e.g. 50% = 0.5). In this situation, the values entered in the five condition states must add up to one for the element.

If a precast concrete panel is badly cracked or broken, the whole precast panel will require replacement. The length in Condition 5 is then given by the length of the panel.

If a steel component that is measured in linear metres (e.g. box girders and trusses), has cracked welds or defective parts which could affect the strength of the whole member, the whole member should be rated as Condition 5. The Principal Engineer Structures should be notified that the member is in Condition 5 and advised that an immediate detailed engineering investigation is required.

1.2.2.3 Components Measured on an Each Basis

When rating components on an each basis, the measurement of a particular condition rating shall be the number of units affected by that condition. Where there is a single component to be rated with varying condition states over sections of the component, an estimation can be made of a portion/percentage of area of the component in the different condition states. The total value in the 'quantity field' must still add up to one for that single component.

e.g.: If there are 4 busway sleepers in total and one sleeper has small areas (estimated at 25%) of Condition 4 and Condition 2 with the remainder of the sleeper (50%) in Condition 1, and the other sleepers are in Condition 1, the overall assessment would be:-

Element	No of	CS1	CS2	CS3	CS4	CS5
Busway Sleeper	4	3.5 (3 sleepers plus 50% of 1 sleeper)	0.25 (25% of 1 sleeper)	0	0.25 (25% of 1 sleeper)	0

Table 5: Example rating components on 'each' basis

1.2.3 Recording Defects

Once the Inspector has completed the condition assessment, they must also record the defects identified for the element inspected. This can be done on the Survey 123 mobile inspection form by selecting a defect type (in the "Element defect type" list box) and adding comments and defect details in the accompanying fields.

The "Element defect types" list box contains a selection of the most common defects and recommended repairs as outlined in the following list:

Repair Defect Type	Repair Defect Type
General Comment	Concrete (Xypex Repair)
Concrete Spalling (Repair)	Concrete (Grout / Epoxy Repair)
Concrete Cracking (Repair)	Settlement Road Approaches
Fretting Concrete	Delineation Installation / Repair
Deck Joint Repair (Design Required)	Approach Obstruction, Drainage
Deck Joints (Clean)	Corrosion Steel (Repair)
Deck Joints (Repair)	Timber Repair
Deck Construction Joints	Retaining Wall General Comment
Bearing Replace Sheet Lead (Design Required)	Retaining Wall Missing Member
	Retaining Wall Growth
Bearing Repair (Design Required)	Retaining Wall Broken Member
Bearing Replace Sheet Lead	Retaining Wall Embankment Slip
Bearing Repair	Retaining Wall Masonry Repoint
Bearing (Clean)	Retaining Wall Masonry Repair
Paint Gantry	Retaining Wall Fill Washout
Paint Touch Up Gantry	Retaining Wall Scour
Paint Girders	Retaining Wall Settlement
Paint Touch Up Girders	Retaining Wall Bowing
Paint Other	Retaining Wall Slope Tension Cracks
Barriers Retaining Wall Repair	Retaining Wall Blocked Drainage
Barriers Gantry Repair	Retaining Wall Seepage
Barriers Approach Repair	Retaining Wall Colour Staining
Barriers Bridge Fence Repair	Retaining Wall Timber Repair
Waterway Scour Fill / Repair	Retaining Wall Concrete Spalling
Waterway Soil / Gravel Removal	Retaining Wall Concrete Cracking
Waterway Growth / Debris Removal	Gantry Structural Repair
Scour Fill / Repair	Gantry Sign Repair
Growth / Debris Removal –	Gantry Electrical, Conduit, Wiring Repair
Abut / Pier / Gird	Noise Wall Repair
Masonry Repoint	Ancillary Asset Repair
Masonry Repair	Pump Station Repair
Mortar Pad Repair	Light, Conduit, Wiring Repair
Approach Pavement Repair	Council / Service Authority (Repair)
Deck Pavement Repair	Public Safety
Deck, Water Table, Scuppers Clean	Urban Art Repair

Table 6: Repair defect types

The Comments field provides the opportunity to explain the recommended repairs in more detail:

- Sometimes the repair type is very specific, but global in intent – e.g. “paint girders”
- In other instances, more detail must be provided for the location of the repair - e.g. “Replace sheet lead in the four (4) bearings nearest the downstream side at Pier 2”.

Defect details recorded should include the defect measurement, type of repair required (refer Section 1.2.4), repair priority (refer Section 1.2.5) and photo filename/s and description/s for the defect.

1.2.3.1 Defects Identified in Previous Inspections

The Survey 123 mobile inspection form includes details and comments for defects identified during previous inspections. Inspectors are required to determine and confirm the status of these previously identified defects and record this in the Survey 123 mobile inspection form as follows:

Previous Comment Status	Basis of selection
Retain	The defect is still apparent. Some wording change may be required and a new photograph (correctly referenced) must be included.
Delete	The defect condition has either altered significantly and a new defect has been recorded, or the affected element may have been replaced and the defect no longer exists. This should also be used where element defects and comments have been duplicated as part of the data migration into Structures Manager – Appendix C Section 4.3.1.3 Step 3 refers.
Repaired	This records that the repair specified in the previous inspection has been completed satisfactorily and the defect no longer exists. If the repair is not regarded as satisfactory this option should still be selected, and a new defect should be recorded.

Table 7: Status of defects identified in previous inspections

1.2.4 Repair Priority

Work that is identified as being required must be allocated a priority code to assist the Asset Manager with suitable programming of the work.

The defects observed by the Inspector and recorded on the Survey 123 mobile inspection form should also detail recommended repairs (refer Section 1.2.5) that should be carried out within reasonable time frames depending on the severity of the defect.

The repair priorities are described as follows.

Priority	Description
Urgent	Structural integrity is threatened, and there is significant risk to the continued safe functioning of the structure.
Essential	Structural integrity may become threatened if identified repairs are not carried out prior to the next scheduled inspection.
Desirable	Structural integrity is not likely to become threatened if identified repairs are not carried out prior to the next scheduled inspection.
Non-essential	The damage is not considered serious at the present time but will most likely deteriorate in future and warrant a higher priority repair recommendation when that occurs.
No action	Minor damage has been observed but does not require immediate repair, and/or is uneconomic to repair at this stage.
No priority	May be used for recording comments only. No damage or deterioration is to be reported with this priority.

Table 8: Repair priority codes

Note that whenever the Inspector's assessment of a defect is assigned URGENT priority, the Principal Engineer Structures must be contacted immediately from the field to discuss the continuing open status of the bridge.

The outcome of that consultation will always result in one of the following: -

- Bridge to remain open to all traffic
- One or more lanes to be closed.
- Bridge closure to all road users.

The above status would normally be coincident with a condition state 5 rating for the affected component.

The use of priority "No action" is to "put the component condition on notice" for an observed defect. This is done by the inspector assigning this as priority "No action" (repair is not warranted yet), but could worsen by the next inspection.

Careful checking at the next inspection may reveal that the defect has worsened as expected, and the inspector should then stipulate a repair, and re-assign the priority to another rating (desirable/non-essential as the case may be).

1.2.5 Type of Repair Required

Where the Repair Priority is rated as any of Urgent, Essential, Desirable or Non-essential, the inspector must also provide a recommendation for the type of repair required. DPTI has a set of standard repair types (listed below) which cover the majority of common repair requirements.

The Survey 123 mobile inspection form includes the ability to add a recommended repair type for each defect. The inspector is required to select the recommended repair from the list of standard repairs or if a standard repair is not considered appropriate, select 'Other repair type' and add a description of the repairs required.

If the inspector wishes to add further details (such as additional documentation or a sketch/diagram of proposed non-standard repairs) this can be done by adding such documentation to the AWS folder for the structure/inspection. Refer to Appendix C for details.

Standard Repair Types - Description
SR01 - Major Repairs to Spalling Concrete
SR02 - Sealing of Deck Joints Covered by Asphaltic Concrete
SR03 - Sealing of Construction Joints in Concrete Decks
SR05 - Epoxy Pressure Injection of Cracks
SR06 - Sealing Leaks in Cracked Concrete with Waterproof Slurry
SR07 - Resealing Deck Joints Not Covered by Asphaltic Concrete
SR08 - Abutment Deck Joint Repair
SR09 - Re-grouting of Bearing Plates
SR11 - Repairs to Masonry Laid in Lime Mortar
SR13 - Double Girder Corrosion Protection
SR14 - Repair of Corroded Girder Webs
SR15 - Repair to Abutment Backwalls
SR16 - XJS Deck Joint Nosing Repair
Other repair type (please specify)

Table 9: Standard repair types

Full details of the above standard repair types can be found in Appendix D of this Manual.

2 PAINT ASSESSMENT AND RUST RATINGS

Reporting the success or failure of protective paint coatings is a very important aspect of the structure management, refer Part 2 Section 1.6. This particularly applies to steel components.

- The deterioration of steel due to corrosion sometimes can reach such serious degrees that structural integrity is threatened. Perforation of girder web sections at supports is a simple example that has happened, or to the extremes shown in the photo below.
- The locations of corrosion and the degree of severity developed are usually far from uniform over the whole of a bridge girder.
- The cost of wholly repainting bridge girders and associated steelwork makes large inroads into maintenance budgets.

Figure 1: Girder corrosion grossly ignored over long period (PNG)

Accordingly, the paint condition and its effectiveness, along with the corrosion that has developed must be described from a local and a global perspective.

This arises due to the very fundamental need to conclude whether the steelwork can remain satisfactorily protected until the next inspection by: -

- Doing nothing, or
- Cleaning and "touching up" the paint coating locally, or
- Cleaning and repainting the entire steelwork under consideration.

Consistent paint condition reporting over several inspections generally should not yield any surprises to the Bridge Management process unless something largely unexpected has occurred since the last inspection. These reports usually reveal a gradual decline in paint sufficiency, allowing the bridge to be assimilated into the repainting program.

Note that a there are a few structures where the concrete girders are painted for aesthetic reasons, and corrosion aspects do not arise. Reporting in this instance will need to be only confined to the paint condition only, and have no wider implication resulting from paint film failure.

2.1 Paint and Galvanising Ratings

Paint and Galvanising Ratings are to be completed using the following ratings schedule.

Rating	Comment
No Rating Assigned	e.g. unpainted temporary structure
Good Condition, no damage apparent	
Chalking of surface, no rust apparent	
Minor rust spots present	
Rust Spots, and minor flaking present	
Corroded areas where paint film missing, flaking and peeling of base metal	
Severe Corrosion present, pitting apparent	

Table 10: Paint and galvanising ratings

In the majority of inspections an assessment will only be required at the overall structure level. However, there are some structures where an assessment will also be required at the element level – this may be as a result of elements being last painted at different times (e.g. the girders in one span may have been painted some years prior to the girders in others). In these instances, the inspection request will detail the need for element level paint assessment.

The Survey 123 mobile inspection form has the capacity to record paint assessments at both the overall structure level and at the element level (where this is required).

2.2 Rust Ratings

Rust Ratings are also to be completed on the Survey 123 mobile inspection form at both the overall structure level and at the element level (where it applies).

2.2.1 Overall Structure

In order to complete a rust rating for the overall structure, the inspector must:

1. Determine average percentage of rust using Figure 37 in Part 2 Section 1.6 of this manual (thumbnail shown in table below), then
2. Select the matching rating number (from 1 to 11) from the table below.

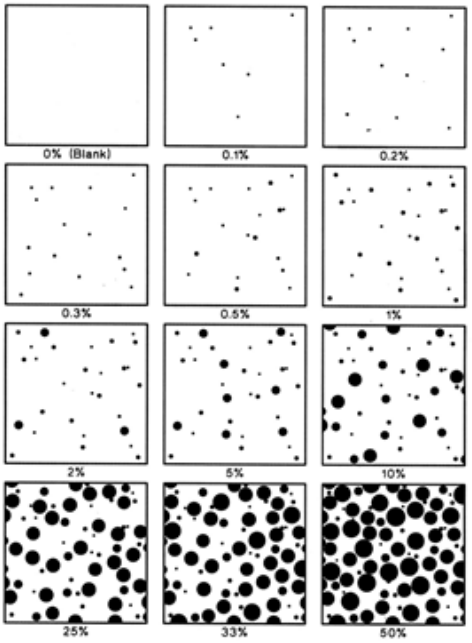
Average rust percentage	
0% (leave blank)	
0.1%	
0.2%	
0.3%	
0.5%	
1%	
2%	
5%	
10%	
25%	
33%	
50%	

Table 11: Rust ratings

2.2.2 Element Level

At an element level, there are 2 rust ratings required. These are 'General Rust Rating' and 'Localised Rust Rating'.

General rust rating is completed on the same basis as the Overall Structure rust rating that is, the Inspector determines the average percentage of rust and assigns the appropriate code from Table 6.

Localised rust rating is an assessment of the worst affected areas of the element. In this case, the Inspector determines the **worst** degree of local rust as a percentage of the total area involved and assigns the appropriate code from Table 11. These values can be significantly different from the average rust percentage.

Coupled with the localised rust rating, further detail is recorded on the Survey 123 mobile inspection form that discloses the location of the severe corrosion areas associated with the girders. This location is to be selected from:

Girder location
Top flange
Bottom flange
Web

Table 12: Location of worst rust on girders

2.2.3 Assessed Repaint Year

This value is used for the bridge repainting program.

The typical paint systems generally cease to be effective on average after about 25 to 35 years. Over that time span, the paint coat deterioration most likely will have been far from uniform, and it is probable that there will have been some local "touch up" painting carried out on one or more occasions. The effectiveness of touch up painting is observed to vary depending on many factors.

However it does delay the need for a total repaint, and helps to match a proposed reconstruction date or at least defer structure replacement, had no touch up painting been carried out at all.

The repaint year should take into account the expected coating life, and also be balanced with the anticipated reconstruction year, which appears on the Survey 123 mobile inspection form.

Obviously it would be nonsense to specify a complete repaint for bridge steelwork only a few years prior to scheduled reconstruction.

When it becomes obvious that this type of non-convergence between repainting and reconstruction years has developed, then there is usually only one course of action in the Bridge Management process. That avenue is to continue with "touch up" painting to preserve structural sufficiency until reconstruction takes place, or reconstruct earlier (usually not a desired option).

2.2.4 Paint Comments

At both the structure and element levels, the Survey 123 mobile inspection form allows the Inspector an opportunity to add comments to clarify the paint condition, repaint date philosophy or other information.

3 OVERALL RATING FOR A STRUCTURE

When the inspection of the components has been completed, the inspector shall assess the overall condition of the structure based on observations made at the site in accordance with the overall rating descriptions shown below, and record their assessment on the Survey 123 mobile inspection form.

Overall Rating
Very Good
Good
Fair
Poor

Table 13: Overall ratings for structures

The structure rating shall primarily be based on the condition of the principal structural components such as girders, headstocks, columns, piles and decks.

The inspector is expected to exercise judgement, based on his or her knowledge and experience, to determine the appropriate overall condition of the structure.

Where a structure is rated as “Poor”, a summary of the key defects contributing to the assessment should be included in the overall rating comments field on the Survey 123 mobile inspection form. Significant defects found in non-critical structural members which expose the road user and/or general public to risk and require urgent attention should also be noted in the ‘comments’ field; for example, defective guardrail and connections to the bridge, damaged or defective bridge railing or loose and insecure assembly joints.

Should an inspector consider that “Poor” is the appropriate overall rating of a structure, the inspector must, on completion (or partial completion if warranted) of the field work, contact the Principal Engineer Structures to discuss the findings of the inspection. If consensus cannot be reached on the overall condition rating and an overall condition rating agreed, the inspection data shall not be finalised in Structures Manager (that is, marked as ‘completed’).

3.1 Reconstruction Date

Overall life expectancy for new structures:

Structure Type	Expected Life	Comments
Bridges	100 years	
Culverts	70 years	
Pipes	60 years	
Bridges and other structures that are designed for limited life, are constructed to comply with a fit for purpose criteria	These structures have an expected design working life set by the economic requirements of the project in consultation with Road Assets Section management such as: - • Bailey bridges that may be required to endure for several years in place, and • Temporary works The working life of these structures are appreciably less than any of those listed above. It is important to recognise that some temporary structures often have limited or even no corrosion protection, and consequently may have an accelerated rate of deterioration. These structures may also be subject to fatigue problems. Accordingly, vigilance is required if and when these structures reach or go beyond their originally designed working life.	

Table 14: Overall structure life expectancy

3.1.1 Reconstruction Date from Current Inspection

During the course of the inspection, the Inspector is required to estimate to remaining expected life of the structure and input a recommended reconstruction date into the Survey 123 mobile inspection form. The recommended reconstruction date is a function of the current condition of the structure and to some extent, the time since construction.

In general, it is anticipated that the reconstruction date for the assessed condition should correspond with the range of years as suggested below.

Assessed Condition	Reported Reconstruction Date
Very Good	Greater than 50 years in the future
Good	20 to 50 years in the future
Fair	10 to 20 years in the future
Poor	Up to 10 years in the future

Table 15: Estimated reconstruction dates

For new bridges, it is assumed that the date of construction year is the “Design year +1” e.g. a bridge with drawings with signed in 2001 was completed during 2002.

The current age of the bridge is the difference between the present date and the construction year.

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