Bridge Inspections - Specification

11/11/2024 4:29 pm +10

In this article:

Article Purpose	To provide specification on a safe and standard method for collecting bridge condition data using Open Data Kit (ODK) data collection systems.
Intended Users	Anyone who is responsible for setting up or carrying out a bridge condition assessment whether it be provincial staff, AMB staff or contracted suppliers.
Last Reviewed	11th November 2024

Background

Bridges are primarily designed to carry traffic across obstacles. To fulfill this function, they must withstand various loads, including the weight of the structure, traffic, wind, scour, temperature changes, and other environmental factors. Since bridges need to be durable and some deterioration is inevitable, they must remain serviceable throughout their lifespan. This means that any deformation, cracking, or damage must stay within acceptable limits to make sure safety standards are maintained.

DoWH intends to maintain up to date data on the condition of their bridges which are to be uploaded to ThinkProject, Asset & Works Management "**AWM**" (formally known as "RAMM" Road Asset Maintenance and Management), which forms the core of the DoWH Road Management System. DoWH relies on the availability of inventory and condition data of every structure to provide reference data, to track the deterioration and to enable the overall management. Therefore, bridges need to be regularly inspected and assessed, to make sure appropriate maintenance is carried out.

Scope of Work

The purpose of the bridge inspection process is to collect required data for network level planning of the preservation and additionally assure the quality of data is sufficient.

The following high-level process provides broader context of the activities involved in the bridge inspection process.

Requirements & Methodology

Step 1: Planning the Inspection

To ensure an orderly, systematic, and efficient inspection, planning the inspection includes determining the sequence of the inspection according to type of inspection, selecting the inspection team, and determining the required activities. This includes:

- Establishing a time schedule for a day, week, or a month.
- Organise the field notes to be used and collating the survey forms required.
- Organise a safety boat when inspecting a river bridge.
- Any other measures to facilitate a thorough and complete inspection.

Step 2: Preparing for the Inspection

This includes organising the proper tools and equipment, reviewing the current Bridge Structure Files (if they exist), locating plans for the structure and preparing the inspection forms. Ideally the Bridge Inspection team should consist of the following personnel:

- Bridge inspector
- Project Engineer/Senior works supervisor
- Armed guard when inspecting crocodile infested rivers.
- Security personnel (where needed)

Suggested Equipment

Bridge inspections can be hazardous for both the inspection team and other road users as the vehicles and the inspectors must stop for the work while there is a lot of movement across the bridge. The inspectors must wear safety vests and vehicles must use special lights. Additionally, caution is necessary when moving under the bridge, on the slopes and in the water. For safety, the inspections must be carried out with at least two team members, both of whom should wear helmets when under the bridge and rubber boots when moving in the water. To keep inspections safe, efficient, and productive, the following equipment is suggested:

- Tripltek tablet
- 50m tape
- Ruler or 5m distance measure tape for taking small measurements and describing the size on photos.
- Binoculars
- Small hammer for delamination detection
- Crack gauge (simple card with different lines with thicknesses starting from 0.1 mm to 2 mm) for concrete damage inspection
- First Aid Kit
- Low rubber boots for moving in low flow rate water
- Brushes
- Bush knife
- Car charger or regular charger with inverter for Tripltek tablet
- Extra batteries for **ALL** equipment
- Ladder*
- Screwdriver for rust and timber testing*
- Hand torch or head light for darker places*
- Laser distance measurer to measure different parameters like length, width etc. Preferably with laser pointer display and for accurate measurement, it should have a tripod*

*Optional equipment

In addition to inspection equipment, a 4-wheel drive vehicle in good condition is required and overall safety equipment like safety vests, traffic cones, gumboots, protective glasses etc. need to be provided for the health and safety of the Bridge Inspectors.

Step 3: Collection of Inventory Information

Before carrying out the bridge condition assessment, it is important to have the correct bridge inventory information. This may have been collected during the inspections that are carried out after construction or reconstruction of a bridge, but if not, it can also be done in the office directly before condition assessment. The main idea of the collection of the inventory information is to prepare the background database for the maintenance and rehabilitation planning. The inventory information contains information on location, bridge geometry, general data, bridge elements, span information, and outer elements. **Without correct inventory information it is not possible to carry out the condition assessment (Step 4).**

Additional information on the process for collecting bridge inventory information can be found here: Collection of Inventory Information - Work Instruction.

Step 4: Performing the Inspection

After obtaining the correct inventory information, the bridge condition inspection can take place.

The main purpose of these inspections can be summarised as:

- To assess the maintenance needs and strategy
- To assess the safety of users and to decide if a structural assessment is needed.
- To reduce the risk of unexpected failure
- To comply with regulations
- To assess the condition of a bridge element
- To decide if a more detailed inspection is needed

These visual condition assessments have a simple routine and will provide an initial indication of the condition of the structure to determine maintenance actions to be taken or if subsequent testing is required.

The assessment of a bridge condition involves inspecting every element unit of the bridge and evaluating each with a condition rating based on a scale of damage present and considering the necessary rehabilitation method. The overall condition is evaluated in 4 different categories shown below.

It should be noted that the overall condition rating of the bridge (Bridge Condition Index or BCI), can have a misleading impact because different states of element deterioration can possess equal condition ratings overall. For this reason, additional smart flags and deterioration process assessment is necessary.

Condition State	Description	Possible Action
0 - Good	The element has no remarkable defects or wearing marks. The overall appearance is as good as new and only small damages can be seen such as bleaching.	Maintenance
1 - Fair	The element has minor superficial damages. Wearing and deterioration processes have occurred. The overall appearance is clean and small deviation of deterioration processes are allowed. Minor repair works are needed.	Small Repair

Condition State	Description	Possible Action
2 - Poor	The element has defects, like corrosion, but the severity of the damages do not affect functional requirements. The overall appearance gives a clear indication that deterioration processes are damaging the element. Repair is needed.	Repair
3 - Severe	The element has defects that could affect the overall or element performance.	Replacement

The overall rating is based on the American Association of State Highway and Transportation Officials (AASHTO) element level health index rating, where condition states are evaluated as a percentage of the overall amount.

Condition assessment is the main information-collecting activity for maintenance planning of a structure and bridge network. Since the condition assessment is carried out visually, it means that it is highly based on the inspector's level of knowledge damages and deterioration processes. Therefore, it is recommended that staff rotation is avoided, and bridges should be inspected by the same people. Further explanation of deterioration processes is provided in Annex B.

Identification of Elements

Current bridge evaluation practice divides the bridge structure into constitutive components that can be commonly clustered into functional groups: **superstructure**, **substructure**, and **equipment** or can be used in establishing the structures orientation.

Primary Function

The elements that are subject to bending due to traffic load are in the '**superstructure' group**, while in the '**substructure' group** are elements mainly subjected to compression. The additional elements in the **'equipment' group** provide protection either to the structure or the users. Also, those elements may provide comfort to the users. The list of bridge elements mainly depends on the bridge structure type and should be defined in the bridge inventory list. The element groups can be seen below. If one needs further explanation, then Annex A provides terminology and explanation.

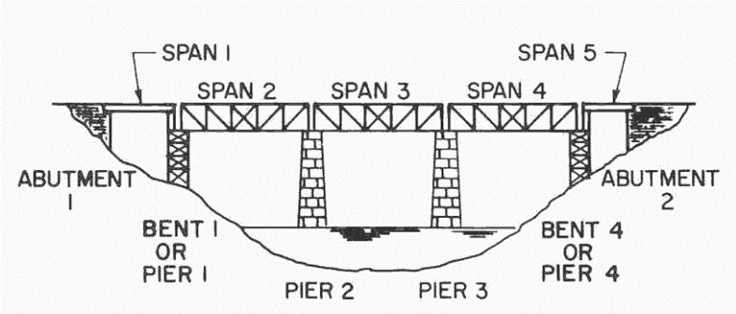
Group	Elements	Primary Function
Superstructure	Deck Slab	Load bearing
	Main girder	Load bearing
	Crossbeam/diaphragm	Load bearing
	Construction joints/Hinges	Load bearing
Substructure	Abutments incl. Wing Walls	Load bearing
	Piers	Load bearing
	Foundations	Load bearing
Equipment	Bearings	Articulation/Load bearing
	Expansion Joints	Articulation
	Drainage	Protection
	Run-on-slab	Comfort
	Waterproofing	Protection

Group	Elements	Primary Function
	Pavement/Overlay	Protection and comfort
	Barrier and Windscreens	Protection and comfort
	Signs	Protection and comfort
	Installations	Comfort

This kind of segmentation is helpful when giving performance predictions for deteriorating bridge elements. This can be done after at least two inspection rounds using historical data, e.g., using the BCI. Given that the element is considered to fail when it reaches its worst condition or another performance goal, then the survival is defined as a condition where the performance goal is not violated.

Location Identification

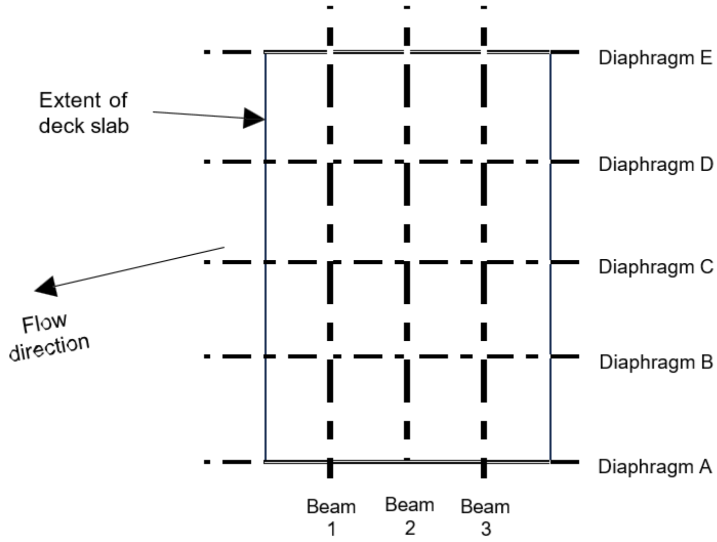
An important activity in establishing the structure's orientation, as well as a system for identifying the various components and elements of the bridge is the identification of the right elements. The identification system used during the inspection should be always the same. The bridge orientation must be determined based on the watercourse flow direction with the upstream aspect to the right of the bridge so that the watercourse flows right to left below the bridge.



Bridge element numbering sequence

The superstructure element numbering system should include the spans, the main beams, the secondary elements (diaphragms, transoms, etc) and, in the case of a truss, the panel points. The spans should be numbered consecutively, with Span 1 located at the beginning of the bridge. Multiple beams should be numbered consecutively from left to right facing in the route direction (refer Figure 2, page 9).

The crossbeams should be denoted consecutively from the beginning of the bridge with a letter, with the first crossbeam (the near abutment diaphragm) labelled as A, leading to the far abutment diaphragm.



Example of one span/3 beam bridge element numbering system

For trusses, the panel numbers should be numbered similarly to the beams, beginning with Panel Point 1. Label both the left and right trusses. Points in the same vertical line have the same number.

Open Data Kit (ODK) Data Collection System for Tripltek Tablet

The ODK data collection format has been set up for the logical process of inspecting the bridge approaches and deck; the superstructure; the substructure and finally the watercourse/features below the bridge. The set-up is as follows:

Page	Set-up
1-3	General data on bridge with salient features
4	Roadway approaching the bridge and deck surfacing elements
5	Span information* – Number of spans • Span 1: length of span, expansion joint data, abutment and wing walls data (2 for single span bridge), deck type and main member types. • Span 2 to (N-1): length of span, expansion joint data, pier data, deck type and main member types. • Span N: length of span, expansion joint data, abutment and wing walls data, deck type and main member types.
6	Roadway departing the bridge
7	Other pertinent details – waterway features, etc.

*All data input for Span 1 follows through to the last span so only those unique features (such as span length, pier height) need to be amended for each span.

Then starts the serious condition assessment with a loop feature for each category of functional group; as follows (note that the loop can continue until all serious defects on the individual elements (or groups, if common defects found)) have been identified and recorded:

- Bridge Element Condition Assessment > 1 (and 2) assesses the condition of the features on the approach, bridge deck and departing road sections.
- Waterway Condition Assessment > 1 (and 2 to N linked to Span Number) assess the condition of the waterway elements below the bridge.

- Superstructure Condition Assessment > 1 (to N with minimum for single condition reference per span).
- Substructure Condition Assessment > 1 (to N with minimum for single condition reference per span).

In order to avoid confusion as to whether an element or group feature has been inspected and found to be in good condition throughout, one Condition Assessment must be completed with 100 inserted into the '0(%) – as new' state **per span** if no defects are found.

For a particular span, a group of elements can be recorded and their condition state noted in a "group" Smart Flag when the condition state is found on all the elements; with any more serious condition state (defect) recorded in a separate Smart Flag for an individual element.

> For example, if all the steel deck beams in a span are in a similar state of defective corrosion this can be recorded in a Smart Flag with the comment "Refers to all beams – light corrosion of the steel beams" with a separate Smart Flag for the outer beam where a more serious corrosion state exists below a defective deck drain. A further Smart Flag needs to be raised for the deck drain repair.

Bridge Element Condition Assessment

To give full flexibility to the Inspector for the input of condition data the Condition Assessments have been set up in a "loop" so that as many Condition Assessments as required to fully describe the condition of the Elements and the defects found on them can be used.

Element	Span No.	Location	Unit	Length	Height	Condition State			
						0	1	2	3
Note 1	Note 2	Note 3				Note 4	Note 4	Note 4	Note 4

Note 1: All Elements described in tables in the Collection of Inventory Information - Work Instruction article.

Note 2: Each Span must be given a Condition Assessment with defects described separately. If there are no defects and the span is in good condition 100% must be inserted in Condition State 0.

Note 3: Location is given above (Bridge element numbering system). Sections of Main Beam can be given as 1A to 1B and likewise sections of secondary elements can be given as B2 to B3.

Note 4: Condition State MUST add up to 100%.

Particular Defect "Smart Flags" and Photographs:

How many Smart Flags	(insert number)	
Smart Flag #	Safety	Comment on Smart Flag
	Failure	

A "safety" Smart Flag **must** be used if, in the opinion of the Inspector, a defect impacts the integrity of the structure to such a degree that the safety of the public or structure are jeopardised.

Sequence of Condition Assessment

The sequence for a bridge of an average length and complexity is as follows:

1. Inspect roadway and deck elements
2. Inspect superstructure elements and bearings

3. Inspect substructure elements

4. Inspect riverbed and slopes

> After or during the inspection, the **Bridge Inspector must take at least one photo of every element group.**

Smart Flags

Road and Work Safety

Photographs for Bridge Inspections

Quality Assurance

> If the data collection is being undertaken by a consultant, DoWH reserves the right for one AMB staff member to join the Consultant's on-site survey team(s) for quality review purposes. The Consultant is to allow for one (only) seating place in its primary survey vehicle to accommodate an AMB staff member and shall provide a minimum of five business days notice of any change of travel dates that have been previously agreed with DoWH (eg. through approval of the Consultant's Workplan). All direct costs (eg. travel airfares, accommodation, per diems etc) incurred by a DoWH staff member accompanying the Consultant's survey team are the responsibility of the client.

Stakeholders

Stakeholder	Role
DoWH AMB	The Asset Management Branch is responsible for this specification and utilising the data for the support of programme development and further analysis.
Provincial Works Manager (PWM)	The PWM is the most senior DoWH role based in each province and should be advised of any data collection to be done on national roads in their province.

Support

References and Additional Reading

Links to further support documents, manuals, publications and other content are included in the table below.

Reference Name / Description

Reference Name / Description