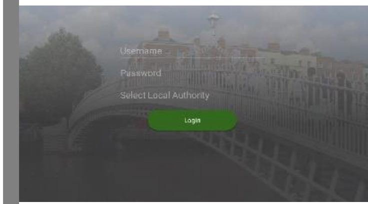
BRIDGE ASSET MANAGEMENT SYSTEM

FOR REGIONAL AND LOCAL ROADS

Guidelines for the creation of an inventory of structures and for performing inspections



An Roinn Iompair,
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

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ABSTRACT

The Bridge Asset Management Project (BAMP) was a project initiated by the Department of Transport, Tourism and Sport to put in place solutions for Local Authorities to manage regional and local road network bridge and structure assets. Although some Local Authorities had their own system of managing these assets, the Department identified the need to implement a method for Local Authorities to manage this in a consistent manner. The Project consisted of four elements, namely; guidelines development; software development; training and procurement framework and has been developed collaboratively by the Department, the DTTAS Support Office, a number of Local Authorities and the LGMA.

This document, entitled 'Bridge Asset Management System for Regional and Local Roads' sets out Guidelines for;

- Identifying the location of the structure and recording its dimensions – the Bridge Inventory Survey (BIS);
- Assigning an initial rating to the structure – Maintenance Inspections (MI);
- Assigning component Condition Ratings to individual structure elements (cCR's) and an overall Condition Rating to the Structure – Engineering Inspections (EI).

The BIS, MI and EI are all carried out using the Mobile Application (*Android only*) developed to supplement these Guidelines, with the data collected residing on the MapRoad Management System. A user guide for this application is contained in Appendix B.

Other sources of data that can be recorded on the PMS system are contained in Chapter 6 with Conservation Principles and Masonry Arch Repair Strategies outlined in Chapter 7.

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Chairmen
Mr. Dominic Mullaney, Department of Transport, Tourism and Sport (DTTAS).
Mr. John McCarthy, Department of Transport, Tourism and Sport (DTTAS).

Members
Ms. Orla Malone, Cavan County Council.
Mr. John Lapthorne, Cork County Council.
Mr. Brian Lawlor, Cork County Council.
Mr. Stephen McCrory, Donegal County Council.
Mr. Brian Cross, DTTAS Support Office (DTTAS SO) (Kildare County Council).
Mr. Bernard Sweeney, DTTAS Support Office (DTTAS SO) (Kildare County Council).
Mr. Ronan O'Dea, Dublin City Council.
Mr. Gordon Rowland, Dublin City Council.
Mr. Sean Breathnach, Galway County Council.
Mr. John Coppinger, Kildare County Council.
Mr. Adrian Barrett, Laois County Council.
Mr. Edmund Kenny, Laois County Council.
Ms. Roisin Smith, Tipperary County Council (LASNTG).
Mr. Pat Fitzgerald, Limerick City & County Council.
Mr. Paul Fox, Local Government Management Agency (LGMA)
Mr. Gary Salter, Sligo County Council.
Mr. Tony O'Grady, South Dublin County Council.

Support
Ms. Claire Byrne, DTTAS Support Office (DTTAS SO) (Kildare County Council)
Mr. Paul Harrington and Mr. Donal O'Connor, Department of Transport, Tourism and Sport (DTTAS)

Application Development
Mr. Ken Dowling and Mr. Sandor Serestyen, Compass Informatics

Peer Review Members
Mr. Darragh Quill, Cork County Council
Mr. Martin Heffernan
Mr. Gerry O'Brien

The Department of Transport, Tourism and Sport (DTTAS) also wishes to acknowledge the input received from a range of Local Authority members in the form of comments and feedback received during the development of the document, the application and its testing and training course pilot events.

USEFUL REFERENCES

- TII Publications – AM-STR-06002 – The Assessment of Road Bridges and Structures (formerly NRA BA 16/14)
- TII Publications – AM-STR-06026 – The Assessment of Road Bridges and Structures (including Erratum No.1, Dec 2014) (formerly NRA BD 21/14)
- TII Publications – AM=STR-06051 – The Conservation of Road Structures**- (**can be applicable to any old Irish bridges, as agreed by LA if so required) (formerly NRA BD 89/15)
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- Guide on Info to accompany application for OPW consent for Bridges and Culverts- Arterial Drainage Act 1945 (section 50) OPW
- BS 7913 – guide to "The principles of the conservation of historic buildings
- BS 6779:4 – Highway parapets for bridges and other structures – Part 4 : Spec for parapets of reinforced and un reinforced masonry construction 1999
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- Ciria C656 – Masonry Arch Bridges: condition, appraisal and remedial treatment
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- BA 74/06 – Assessment of scour at highway bridges
- BD 63/07 – Inspection of Highway Structures
- Notes on the Guidance on the Specification for Road Works - Series NG 2400 –Brickwork, Blockwork and Stonework- GSW -02400 Dec 2013
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GLOSSARY OF TERMS

Courtesy: *'Ireland's Bridges' - Ronald Cox and Michael Gould. Wolfhound Press, Dublin.*

AADT Annual Average Daily Traffic

Abutment the resistance offered to the horizontal thrust of arch or, more generally, the body which provides the resistance, e.g. at the ends of a bridge

Aedicule a niche flanked by columns to form a recess, sometimes to accommodate a statue

Anchorage the means of restraining or anchoring the ends of the suspended cable(s) of a suspension bridge

Arch a structural element with a curved soffit capable of spanning a horizontal gap and of carrying its own weight and other loads wholly or largely by internal compression

Arch Ring the assembly of voussoirs in a masonry arch between the extrados and the intrados (also arch rib)

Archivolt a projecting moulding that follows the curve of a masonry arch on top of the extrados

Ashlar masonry comprising stones that have been carefully hewn and worked

BAMP *Bridge Asset Management Project*

Balustrade a railing supported by a series of short ornamental pillars or balusters

Beam a usually straight structural member capable of spanning a horizontal gap and supporting loads and transferring them to its supports by its resistance to bending

Bearing the support of a beam or girder or the length (or area) of the beam or girder that rests on its supports

Bending Moment an angular rotation, being the product of a transverse force and the perpendicular distance to the point at which the moment acts

BIS Bridge Inventory Survey

Bowstring Girder a latticed girder the longitudinal profile, of which has a top flange or chord that is arched or bowed

Box Girder a hollow girder having a square, rectangular or trapezoidal cross section

BRC Fabric a continuous wire mesh of drawn wired laid in concrete along the lines where the tension is greatest

Buckled Plate a cast or wrought-iron square, rectangular plate having a convex form to resist downward loads

Cable-stayed a form of suspension bridge in which the deck is supported by a series of cables radiating from the towers

Caisson watertight, open-topped box within which the foundations of piers may be constructed

Cantilever a structural member fixed at one end and frequently unsupported along its length, although it may be propped by an intermediate support

Cast-Iron iron that is poured molten into moulds to form castings of the required shape

Cement a powdery substance made by calcining lime and clay, mixed with water to form mortar or used in concrete to bind the aggregate

Centring the temporary structure used to support an arch during its erection

Chord the top or bottom, generally horizontal, part of a metal, timber, or concrete girder

Clapper Bridge a bridge across a shallow river bed comprising a series of low stone piers spanned by stone slabs

Column a vertical structural member carrying a downward load in compression

Compression a force that tends to shorten a structural member; the opposite of tension

Concrete a composition of gravel, sand, cement and water

Continuous Beam a beam of several spans in the same straight line joined together in such a way that a known load on one span will produce an effect on the others

Coping a defined top course of masonry or lime/ cement-based material on bridge parapet wing and retaining walls)

Corne de Vache French term for tapered chamfering of the edges of arches

Cornice a horizontal moulded projection crowning a building of structure

cCR Component Condition Rating

cSAC candidate Special Area for Conservation

CR Condition Rating

Crenelation a battlement outline, sometimes evident in external arch voussoirs, where alternate stones project above their neighbour around the extrados providing a crenelated feature

Crown the highest point of an arch, about the keystone abutment

Cutwater the end of a bridge pier protruding beyond the face of the spandrel and shaped in order to divide the stream of water and deflect floating objects away from the bridge

Dead Load a load of constant magnitude, e.g. the self-weight of a bridge structure and any permanent loads fixed to it

Deck the bridge floor designed to carry the traffic

Distributed Load the uniform or variable load distributed along a bridge

DTTAS Department of Transport, Tourism and Sport

Duct a channel or tube for conveying fluid, cables, etc., especially public utility services

Dynamic or ***Live Load*** a load that is applied or changes sufficiently rapidly to bring into play significant inertial resistances

EI Engineering Inspections

Equilibrium the state reached when the forces acting on a body are balanced

Expansion Joint a gap or joint in a structural member (especially concrete) to allow for thermal expansion of the member

Extrados the convex surface of an arch

Fieldstone stone occurring randomly on the surface of the ground in a locality

Fill material, such as gravel, earth or rubble, used to fill the space between spandrels, behind retaining wall, and to construct embankments

Flange a wide flat projection on a structural member, usually at right angles to the main member

Girder a structural component comprising tension and compression flanges connected by bracing or solid web elements

Grouting the filling of the voids in structural elements with a thin fluid mortar or cement,

Guniting the application of a layer or mortar or concrete by projecting it at high speed on to a surface

Hanger a vertical tension member connecting the deck of a suspension bridge with the suspended cable

Haunch the part of an arch between the springing and the crown

Haunching (or backing) material, usually of lower quality, used to fill in or give support behind at structure, in masonry arches typically over the portions of the span directly on the extrados

Hennibique System a system of concrete reinforcement consisting of a combination of alternate straight bars with ends bent up at an angle, with vertical V-bars, or stirrups, of flat iron passing around the straight bars and reaching nearly to the top of the beam

Howe Truss a type of lattice girder in which the diagonal bracing elements are in compression

Impost the upper course of a pillar carrying an arch

Intrados the concave surface of an arch

Jack Arch a brick or concrete arch spanning between the flanges of girder for the purpose of transferring loads from the fill to the girders

Kabn System a system of concrete reinforcement in which the square section has horizontal extensions that are broken away and bent up (or down) to provide bond and resistance to shearing ***forces***

Keystone the voussoir placed last at the crown (top) of an arch

Latticed Girder or ***Truss*** a metal girder or truss in which the top and bottom flanges are connected by a series of criss-crossing diagonal members

LGMA Local Government Management Agency

LHB Left-hand river bank

Load the forces applied to a structure

Masonry stonework or the work of a mason

Mass Concrete concrete containing no reinforcement

MEXE Military Engineering Experimental Establishment

MI Maintenance Inspections

Mild Steel steel containing a small percentage of carbon, strong and tough but not easily tempered

Mortar the matrix used in the beds and joints in masonry, to adhere and bind, fill the voids, and distribute the pressures exerted by the loads

Moss Bar reinforcement bar of rail-type section

NHA Natural Heritage Area

NIAH National Inventory of Architectural Heritage (NIAH)

Oriel decorative circular feature in the spandrel wall, normally over a pier

OPW Office of Public Works

Patrasses metal spreader plates connected by a tie road inserted through the spandrels of a masonry bridge to prevent them from moving outwards

PMS Pavement Management System

Pediment the triangular part of a building or structure surmounting a series of columns

Pier an intermediate support between two elements of the superstructure of a bridge

Pilaster a rectangular column, especially one projecting from a wall or other vertical surface

Pile a vertical member driven or in some other way placed in the ground to provide vertical support for a structure

Plate Girder a girder in which the top and bottom flanges are connected by a solid vertical web

Pointed arches masonry arches with geometrically defined apex at crown, Tudor and various gothic arches fall within this category.

Portal Frame a frame consisting of two uprights connected at the top by a third member, which may be horizontal, sloping or curved

Post-Tensioning a method of pre-stressing concrete, in which the cables are pulled, or the concrete is jacked up after it has been poured

Pratt Truss a girder having a mixture of vertical (compression) and sloping (tension) members connecting the top and bottom flanges

Pre-cast Concrete concrete component that are cast and partly matured on-site or in a factory before being lifted into their position in a structure

Prefabrication the fabrication of structural elements in a factory or on-site-yard prior to their being used in a structure

Prestressed Concrete concrete in which cracking and tensile forces are eliminated or greatly reduced by compressing it with stretched cables within it or by pressure from abutments

Pre-tensioning concrete members are pre-cast, usually in a factory, with the tensioned wires embedded in them, the wires are anchored, either against the moulds or, against permanent abutments in the ground. After hardening, the concrete is released from the mould and the wires are cut off at the anchorage

Puddle Clay clay worked to a suitable consistency to form a barrier to the passage of water

Putlog holes holes left in a masonry wall to provide support for horizontal member, typically to support arch centering

Refuge a recess in the parapet wall of a masonry arch bridge, usually built up from a cutwater

Reinforced Concrete concrete containing reinforcement to counter the inherent inability of concrete to resist tensile and shear forces

Reinforcement steel rods or mesh embedded in concrete to plaster or mortar and bonded to it

Relieving Arch an arch designed to remove load from the main structure

Retaining Wall a wall built to prevent the movement of loose material or fill

RHB Right-hand river bank

Rib a band of masonry projecting from the soffit of a masonry arch

Rise the vertical distance from the springings to the crown of an arch

Rolled Steel Joint (RSJ) a solid I-section steel girder passed through a hot-rolling mill

Rubble Stone quarried stones of angular shape and random size

Rusticated Ashlar ashlar on which the face is left rough and stands out from the joints, the stones being cut back at the edges by bevelling or rebating

Segmental Arch one whose intrados is less than a semi-circle

Semi-Circular Arch one whose intrados is a semi-circle

Shear or Shear Force a sliding force acting across a beam near its support

Sheet Piles flat timber or trough-section steel piles driven edge to edge to form a vertical barrier against ingress of material or water

Simply Supported in the case of a beam, supported at or near its two ends in such a way that it is free at both of then to rotate in the plane of the loads and free at one of them to expand or contract longitudinally

Skewback the stones forming the slopes on the piers or abutments on which the lowest ring stones rest in segmental arches

Skirt a protective surround to a bridge pier to counter the scouring action of a river

Slab a structural element capable of spanning a horizontal gap in the manner of a beam, but extended laterally

Soffit the underside of an arch or beam

SOP Safe (or Standard) Operating Procedure

Span the distance between the supports of an arch or beam

Spandrel the space between the extrados of an arch, or two adjacent arches, and the bottom of the road metal or road plates

SPA Special Protection Areas

Springing the lower point on an arch at which it ‘springs’ from an abutment or pier

Springing course a projecting or defined course defining the lower point from which an arch ‘springs' from abutment or pier.

SSWP Safe System of Work Plan

Steel iron in which the carbon content has been reduced by blowing an air blast through the molten metal to increase its strength and improve its ductility

Stiffener a rib-like projection from a thin structural member loaded in compression to increase the stiffness in bending and thereby prevent buckling

Strain the change in shape or dimensions resulting from stress (may be tensile, compressive, or shear)

Stress the effect of a load on a structure. Measured as force per unit of resisting area (may be tensile, compressive, or shear)

String Course horizontal courses (sometimes projecting or moulded) built into the faces of walls to act as a tie or to emphasise the structure, often used in masonry bridges to define the separation of spandrel from parapet walls.

Strut a structural member absorbing a compressive or ‘pushing’ force

Superstructure the upper part of a bridge, excluding the foundation and at least the lower parts of the piers

Suspender a vertical hanger in a suspension bridge, by which the roadway is carried on the cables

Swing Bridge a bridge that swings open horizontally to allow a ship or barge to pass. It may have one leaf pivoted centrally or two equal leaves pivoted about their ends

Tendon a pre-stressing cable

Tension a pulling force or stress

Three-centred Arch an arch whose intrados comprises portions of three circular arcs

Through-Arch an arch through which the deck passes

Thrust the resultant force is an arch acting towards the abutment

Tie a structural member transmitting a tensile or ‘pulling’ force

Tie bar a metal rod inserted to counter movement apart of two structural elements

Torsion a twisting force

Truss a framework in which the individual members experience only tension or compression. The truss as a structural component supports loads like a bean or girder

UI Unique Identifier

Underpin to excavate beneath the foundation of piers or abutments and extend them downwards in masonry or concrete

Voussoir an arch stone of tapered or wedge shape

Waterway the distance between the end abutments less the sum of the pier thickness

Web the material in a girder between the flanges

Wrought-Iron iron made in bars by beating or rolling out the slag and impurities in a semi-molten state on the furnace hearth, thus giving the metal a fibrous structure and improving its ductility or ability to bend

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INTRODUCTION

1 INTRODUCTION

It is estimated that there are more than 45,000 bridges supporting public roads in the Republic of Ireland. Transport Infrastructure Ireland (TII) have responsibility for structures on the National road network, totalling approximately 3,000. The remainder, on Regional and Local roads, are the responsibility of Local Authorities (LA's). This constitutes a vast infrastructural asset. It is further estimated that 80% of the Regional and Local road bridges are masonry arch structures and therefore more than 130 years old, with many thousands over 200 years old, all representing a significant part of our built heritage that is still functioning and carrying moving loads unimaginable by their builders.

Ancient stone bridging techniques in Ireland began with clapper stone structures (simple slabs or beams of stone spanning between large stones spaced across a river). Stone arches and arch bridges arrived with the Religious from France in the twelfth century paralleling the construction of abbeys and monasteries. Abbeytown Bridge, adjacent to the Cistercian Abbey ruins in Boyle, County Roscommon is thought to have been completed before 1220 AD (according to O'Keefe and Simington: 'Irish Stone Bridges'). The bridge comprises five 10' spans, has never been widened nor seemingly strengthened and is still open to vehicular traffic, some 800 years later.

Road restoration and strengthening works constitutes a large proportion of a Local Authority's annual grant expenditure with multi-annual programmes now involving the Pavement Management System. Bridge restoration and maintenance is often overlooked, despite the obvious serious consequences of failure and the societal and heritage value of these predominantly old yet robust structures.

There is considerable variation between Local Authorities across the country regarding the quality of the bridge stock data and quality and attention to repairs. The Department of Transport, Tourism and Sport (DTTAS) intends that these Guidelines, and the associated mobile Application, will provide a means of collecting the essential data to quantify the number, type and condition of the bridge stock, in a practical and expeditious manner and within the capacity of the Local Authorities, and to promote the appropriate and important repairs of these assets. The data recorded using the Application will reside on the current MapRoad Pavement Management System.

Abbeytown Bridge, Boyle, County Roscommon. Open to vehicular traffic and celebrating its 800th birthday about now! Concrete skirts to the piers were added during the mid-twentieth century but, other than that, the bridge appears to be essentially 'as built'.

These Guidelines have been produced to assist those involved in the management of this asset to;

a. effectively record existing relevant details relating to the structure by means of a ***Bridge Inventory Survey (BIS)*** ; see section 1.1.

b. carry out an initial inspection of the structure and assign a basic rating (red/amber/green), by means of a ***Maintenance Inspection (MI)*** ; see section 1.2.

c. carry out a detailed inspection of the structure and assign a condition rating to the structure by means of an ***Engineering Inspection (EI)*** ; see section 1.3.

1.1 Bridge Inventory Survey (BIS)

The Bridge Inventory Survey (BIS) provides a means of creating an inventory of bridges and culverts relatively quickly, particularly for those that are newly embarking on this asset inventory. The Application allows the user to establish the existence of a structure and its location, its type, materials, basic size and appearance, including photographs. See Chapter 3 for further details. Initial observations regarding defects can also be noted in the BIS, however, it is intended that comments regarding the condition of the structure are recorded when carrying out the Maintenance or Engineering Inspections.

DATA COLLECTED DURING THE BIS										
Access Hazards	Steep Banks	Deep Water	Fast moving Water	Very tall structure	Unstable Bed	Vegetation	IAPS	Multiple selection		
	Fencing restricts access	Illegal Dumping	Livestock	Traffic	Services	Bridge Condition	Specialised Access Required			
Culvert	y/n (culvert type if y)									
***Structure Type**	Arch	Beam	Slab	Truss	Pipe	Box Culvert	Composite	Clapper	Others	Not surveyed
Captured Location	x.y location automatically captured by application									
Location Description	Text entry									
Road Number	road number automatically detected by application									
***Structure Number (calculated)**	Structure number automatically generated by application									
Structure Name (plate)	Text entry									
Structure Name (alias)	Text entry									
***Structure Material**	Masonry	Concrete	Metal	Timber	Plastic	Combined				
***Number of Spans**	Integer									
***Total Span**	Decimal									
***Max Span**	Decimal (if Number of Spans >1)									
***Min Span**	Decimal (if Number of Spans >1)									
***Structure Length**	Decimal									
***Structure Width**	Decimal									
Principal Function	Public Road	Footway	Cycleway	Other						
Structure Over	Road	Rail	Footway	Cycleway	Canal	Other				
Structure Under	Road	Rail	Footway	Cycleway	Canal	Other				
***Height of Opening**	Decimal									
Skew Angle	Integer (estimate to ±15°)						*** = Mandatory Item**			
Height Restriction	Decimal and y/n for presence of warning signage									
Weight Restriction	y/n and Decimal									
Flood Relief Openings	y/n and Decimal									
Services Present?	y/n					***Photographs (max 4)**				

Table 1.1 – Data collected during BIS

General Note:

- All dimensions inputted in the Application and other records, for consistency, shall be in metres.
- The hydrology industry standard for river bank and abutment description has been adopted, i.e. left-hand river bank (LHB) is always when the observer is facing Downstream – i.e. water flowing towards the observer' back with spans numbered from this bank to the right-hand river bank (RHB)

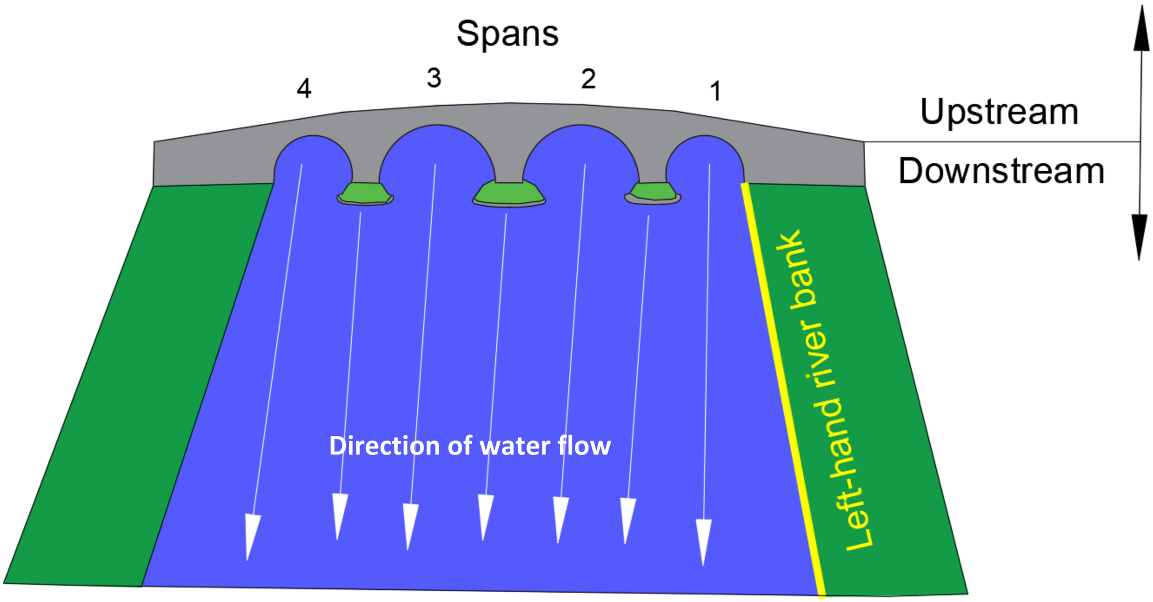


Figure 1.1 – Upstream/Downstream

The Bridge Inventory Survey is **NOT INTENDED** to be a detailed survey of the structure. It is merely a process to establish all the pertinent information in relation to the characteristics and elements of the structure. The Maintenance and Engineering Inspections provide for collecting bridge defect information and the classification of the defects. It is also advised that that a Maintenance Inspection is carried out at the same time as the Bridge Inventory Survey.

1.2 Maintenance Inspections (MI)

The user also has the option of immediately carrying out a Maintenance Inspection using the Application (once a BIS has been saved and uploaded). This inspection assigns a **Red** (*Bad indication*), **Amber** (*Moderate indication*) or **Green** (*Good indication*) rating to the structure considering the ratings awarded by the Inspector under 6 headings; 3 structural and 3 non-structural.

ELEMENT	TYPE
External walls	Structural
Abutments and piers	Structural
Soffit and deck	Structural
Parapets	Non-Structural
Access and egress	Non-Structural
Vegetation	Non-Structural

Table 1.2 – Maintenance Inspections – Element Types

The worst rating of the three structural elements determines the overall Maintenance Inspection rating of the structure. See Chapter 4.

1.3 Engineering Inspections (EI)

The Engineer can also carry out a more detailed inspection, an Engineering Inspection, using the Application. This inspection assigns rating of **1-5** to the structure under 14 headings; 8 structural and 6 non-structural. See Chapter 5.

ELEMENT	TYPE
Wingwalls/retaining walls and spandrels	Structural
Abutments	Structural
Piers	Structural
Spandrels	Structural
Arch barrels/external voussoirs	Structural
Beams/girders	Structural
Slab/deck	Structural
Riverbed	Structural
Bridge surface	Non-Structural
Footpath/verges/rubbing strips/medians	Non-Structural
Parapets and safety rails	Non-Structural
Embankments and revetments	Non-Structural
Bearings/expansion joint	Non-Structural
Other elements and special features	Non-Structural

Table 1.3 – Engineering Inspections – Element Types

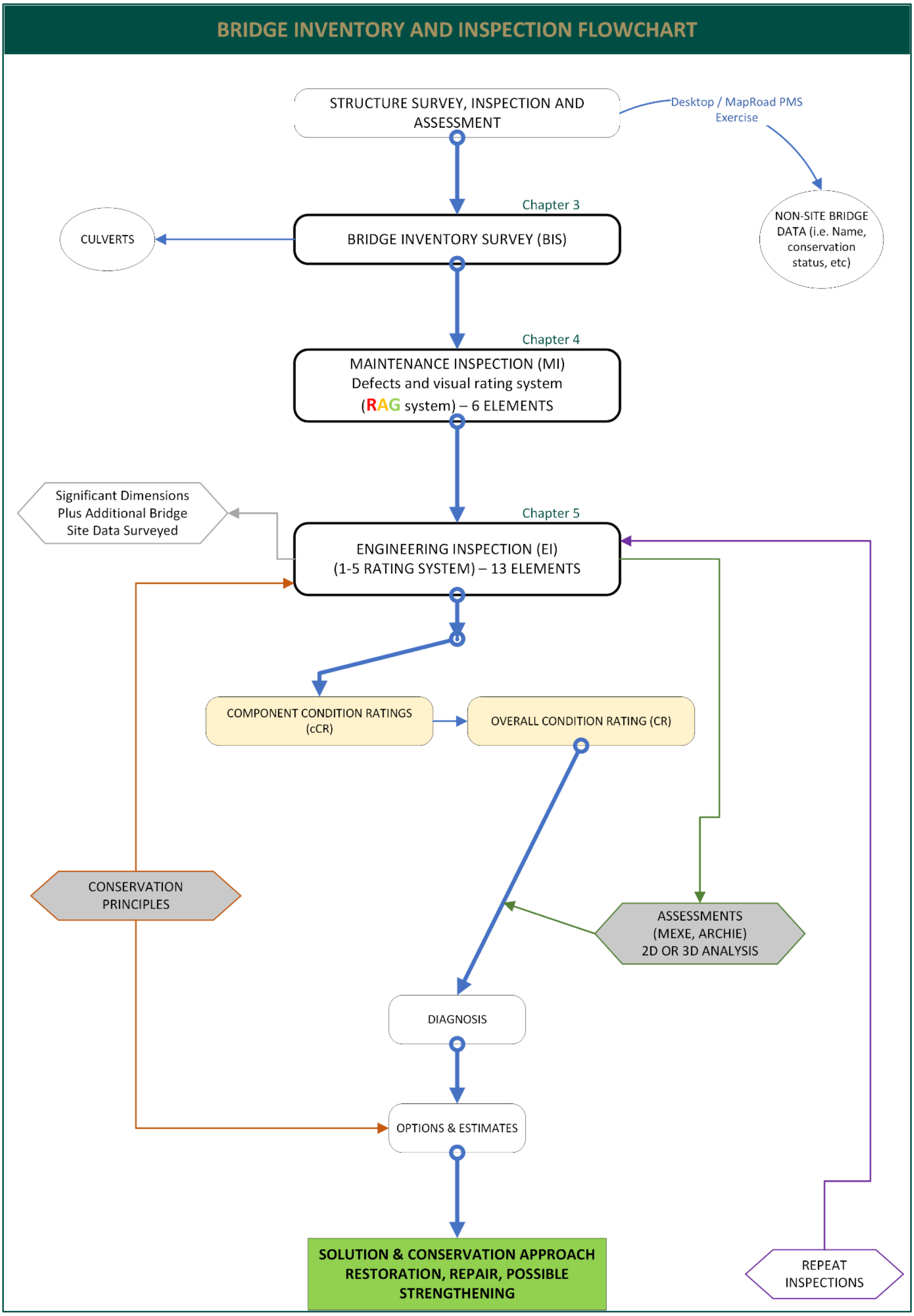


Figure 1.2 – Inventory and Inspection Flowchart

2

HEALTH AND SAFETY

2 HEALTH AND SAFETY

2.1 General

The most important part of any bridge survey / inspection is the safety, health and well-being of the operative undertaking the work. This section of the document aims to provide awareness of some the common health and safety hazards applicable when undertaking a bridge inspection / survey.

It is, however, ***the duty of each local Authority to have the appropriate policies and procedures in place to safely manage their employees undertaking bridge surveys and inspections.***

2.2 The Corporate Safety Management System

Each Local Authority by law will have a safety management system and by law each employee is duty bound to comply with it. For employees undertaking bridge surveys or Inspections this will be the primary source of health and safety. The safety management system will likely include:

- Safety Statement
- Policies
- Generic Risk Assessments
- Safe Operating Procedures (SOP) / Safe System of Work Plan (SSWP)

Bridge surveyors and inspectors should familiarise themselves with their corporate safety management system before progressing with the work and comply with the requirements in full.

2.3 Site Specific Risk Assessment

It is important to recognise that each bridge site is different and whilst there may a number of hazards common to all bridge sites there will also be a number of hazards specific to that particular site. It is, therefore, imperative that the surveyor / inspector undertake and record a site-specific risk assessment in order to identify the appropriate controls required to undertake a safe survey or inspection. The survey or inspection should only proceed when the required controls are in place and should only include the parts of the survey or inspection that can be safely undertaken. A good risk assessment helps to ensure safety when undertaking this type of work and, remember:

IF IT IS NOT SAFE, DON'T DO IT

2.4 Safety Considerations Associated with Bridge Surveys and Inspections

Each Local Authority's own corporate Safety Management System will be the primary source of health and safety information for employees engaged in bridge surveys and inspections and must be complied with in full. Furthermore, it is necessary for the surveyor / inspector to assess the risk at each site. The following is a list of common hazards that may affect safety and health of the employee when undertaking bridge surveys and inspections. It should be noted that this list is not exhaustive and that there may be other hazards particular to a specific site that must also be considered.

2.4.1 Lone Working

The surveyor / inspector should consider the following when undertaking a survey or inspection on their own:

- If something were to happen to you on site how would you raise the alarm?
- How would the people sent to help you know where to find you?

Bridge surveyors / inspectors should refer to their Local Authority Safety Management System's policies and procedures in relation to lone working and, if permitted, ensure that they have adequate controls in place.

2.4.2 Personal Health and Ability

Bridge surveyors and inspectors should be aware of their own abilities and limitations. Bridge work of this nature can, at times, be a strenuous activity and the surveyor / inspector should only work within their own capabilities.

2.4.3 Weather

Consider the preceding and current and forecasted weather conditions as they may prevent the undertaking of a safe inspection.

2.4.4 Traffic

Each site is unique and must be risk assessed. Consider where cars can safely be parked and how to safely travel between your vehicle and the bridge. Consider what controls will be required to undertake a safe inspection. Note: railway lines must never be accessed.

2.4.5 Working at Height

It should be remembered that each bridge is effectively a retaining structure therefore there is the potential to fall from height, particularly on site where parapets have been damaged. There is also a risk of items falling from above. Bridge surveyors should always refer to the requirements of their Corporate Safety Management Systems and assess the risk before conducting a survey or inspection. It should be noted that slips, trips and falls are responsible for large numbers of accidents in the work place.

2.4.6 Access and Egress

It is essential that bridge surveyors and inspectors identify a safe and easy means of access and egress to any bridge before approaching the structure. Riverbanks can be overgrown which can conceal hazards such as vertical faces at the river's edge. Riverbanks can be steep, unstable and slippery. Fencing, briars and thorns can cause cuts or abrasions and can be trip hazards whilst invasive species such as giant hog weed can cause serious burns. Therefore, access and egress should always be risk assessed.

2.4.7 Water

There is always a risk of drowning when work close to water, surveyors and inspectors are directed to their Local Authority's own Safety Management System in the first instance to determine the Corporate policy in relation to working close to water. Particular hazards are deep water, fast flowing waters and tidal waters and the surveyor / inspector should always undertake a site-specific risk assessment in relation to this activity and implement the required controls.

2.4.8 *Riverbeds*

There are a number of hazards which surveyors and inspectors should be aware of within the riverbed. Riverbeds can be unstable, have deep concealed holes or rocks and have muddy or silty deposits which are a risk to the stability and safety of surveyor / inspector. Polished masonry floors, mineral deposits and weed growth and make conditions underfoot slippery for the surveyor / inspector. The surveyor / inspector should always undertake a site-specific risk assessment in relation to this activity and implement the required controls.

2.4.9 *Confined Spaces*

Bridge surveyors and inspectors should be aware that some structures are confined spaces and entry is a high-risk activity which should only be undertaken by appropriately trained personnel with the required safety equipment. Surveyors and inspectors are directed to their Local Authorities own Safety Management System for information in relation to this activity.

2.4.10 *Welfare*

Bridge surveyors and inspectors should make adequate provisions for cleaning and sanitising their hands whilst on site and for first aid. Leptospirosis (Weil's disease) is spread in animals' urine, particularly rats, and can enter the body through ingestion (eating), open wounds (cuts and abrasions) and through contact with bodily fluid (rubbing your eyes). Therefore, good sanitation and personal hygiene is essential on site.

2.4.11 *Other Factors*

There are a range of factors that could affect the health safety and welfare of a surveyors and inspectors at a particular site. Other factors that could affect the safety of bridge surveyors and inspectors include:

- Livestock
- Dogs
- Public / landowner interaction
- Overhead lines
- Sewerage
- Illegal dumping
- Unstable structures

It should be noted that the list of hazards provided is not exhaustive and that other hazards may be present on any site. Therefore, it is essential that all bridge surveyors and inspectors undertake a thorough risk assessment, record the findings and then implement the required controls before undertaking any survey or inspection.

2.5 Importance of Health and Safety

Workplace accidents where people are harmed can have life changing consequences for the individuals involved, their families and friends. There are legal obligations on both employers and employees to ensure health and safety at work. It is imperative that these work activities are undertaken in compliance with the Local Authority's own Safety Management System, are fully risk assessed and that sufficient precautions have been undertaken to prevent harm to yourself or a colleague. Remember;

IF IT IS NOT SAFE, DON'T DO IT

3

BRIDGE INVENTORY SURVEY

3 BRIDGE INVENTORY SURVEY

3.1 Introduction

The Bridge Inventory Survey (BIS) has been developed to capture the most important pieces of information in relation to the national asset of structures, namely, the amount, type and location. There are three sections within the Application which has been developed to allow the user to use any section on a standalone basis, i.e. the user does not have to carry out a BIS and a Maintenance Inspection (MI) or Engineering Inspection (EI) at the same time. Local Authority resources will invariably dictate the order that the survey or investigations are carried out, however, it is expected that a Bridge Inventory Survey (BIS) will be carried out first to at least quantify the asset for the Local Authority. Maintenance or Engineering Inspections can then be programmed by the Local Authority. It would, however, be beneficial to carry out the BIS, MI, and, if required, the EI at the same visit to a bridge.

3.2 Creating a new Bridge Record

If this is a new or first survey of a structure on a public road the Application will show the user is located at a road and watercourse intersection point (from OS map interrogation of watercourse and road line intersect). The user then establishes if a structure is present or not and, if so, whether it is a bridge or culvert and then proceeds to collect data.

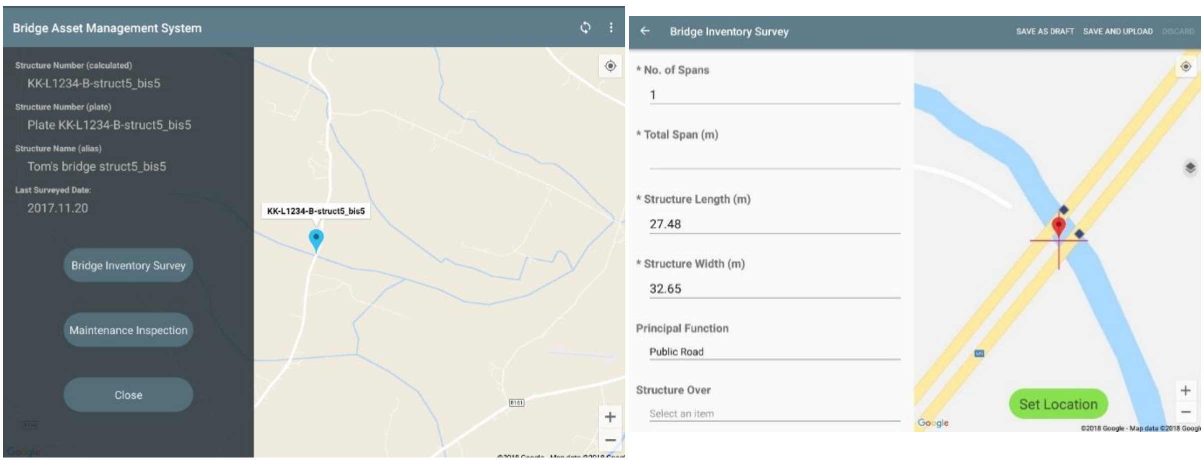


Figure 3.1 – Application Opening Display

Occasionally, it may be desirable to include a bridge or culvert not on a public road e.g. on a Greenway, these structures can be inputted manually on site in the Application. The ID point should be the approximate centre of the bridge, i.e. the centre of the central span in a multi-spanned structure.

3.3 Structure Location

The structure location will be identified by the Application to GPS (latitude/longitude) co-ordinates and the road number will be automatically identified by the Application. The user can enter text in the application or in the PMS Desktop interface to help define the structure location, e.g. the local name, townland, adjacent physical features, road junctions etc.

3.4 Road Number

This is the number of the road as it appears on the Local Authority roads schedule. Each road in the Local Authority has an individual number. The road number will have a prefix of N for National roads, R for Regional roads and L for Local roads. This will be followed by an individual road number of between 2 and 5 digits. The road number will be generated automatically by the Application. The road number will form the first part of the bridge number.

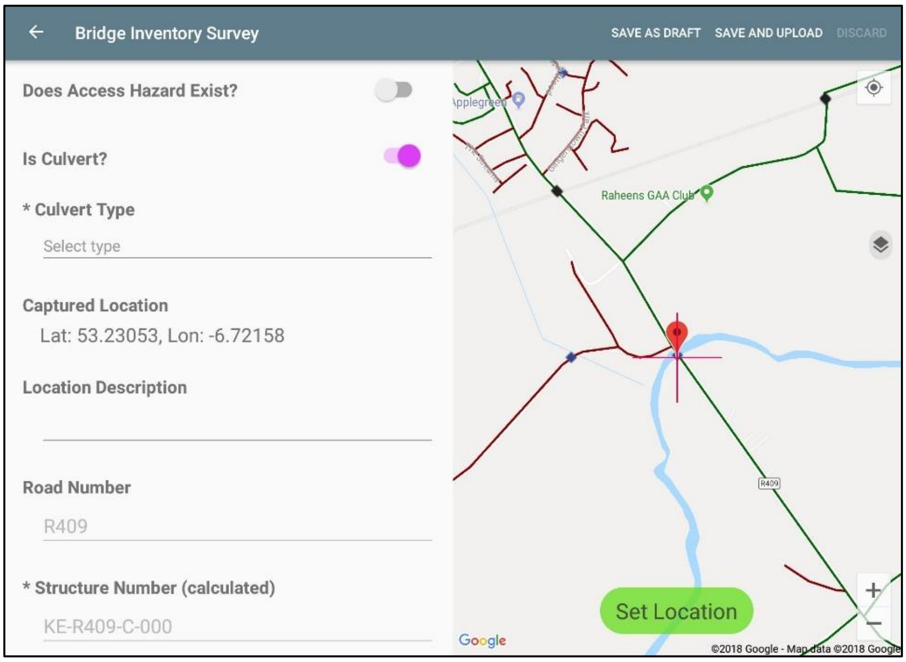


Figure 3.2 – Road Number

3.5 Structure Number

This is an individual number assigned to each structure. The first part of the bridge number shall be the County code/abbreviation (i.e. DL for Donegal), the next part will be the road number without the section numbers (i.e. R257). The next part of the number shall be the individual bridge number. The bridge number will be a three-digit number that increases sequentially in units of 10, preferably in the same direction that the road section numbers increase. The first part of the structure code, after the road number, shall be a letter prefix; B for Bridges or C for culverts. The road number will be generated automatically by the Application (e.g. DL-*R257*-B-010).

For example, the numbering system for the first three structures found on a length of road (R238) would be as follows: R238–B-000 (1st structure found), R238-B-010 (second structure found), R238-C-020 (third structure found; note this structure is a culvert). All Structures recorded, therefore, will have a Unique Identifier (UI) assigned nationally.

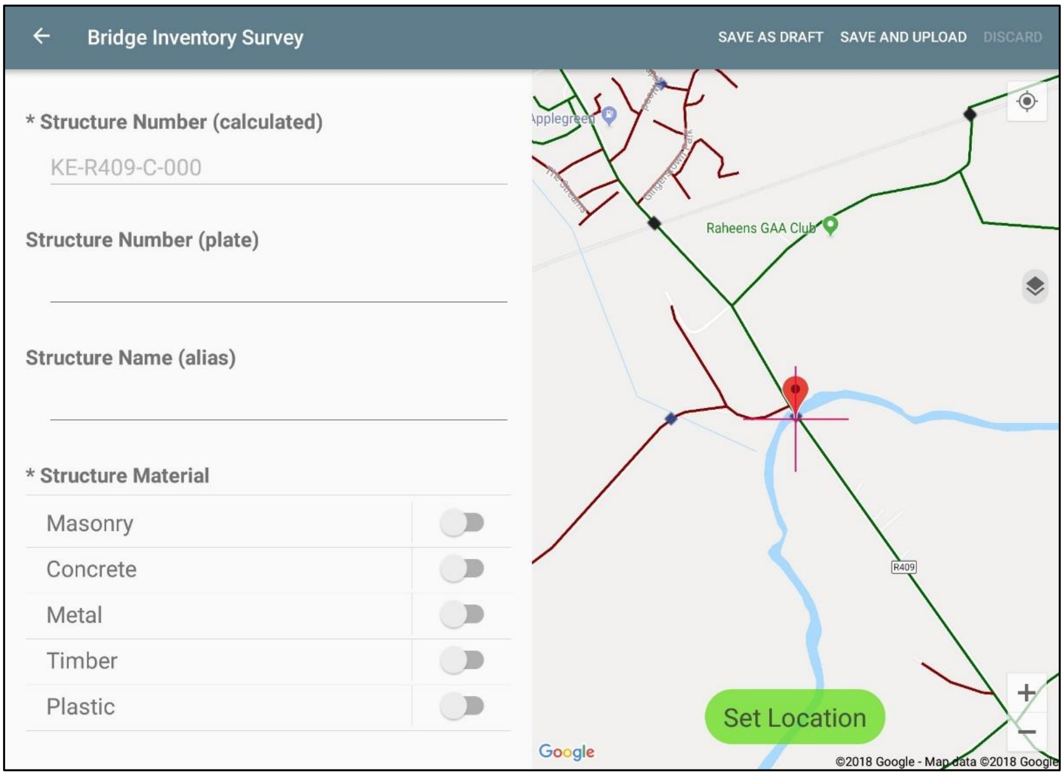


Figure 3.3 – Structure Number

3.6 Structure Types

For the Bridge Inventory Survey (BIS), a simplified list of bridge and culvert types has been included. The bridge type relates to the main construction type of the bridge superstructure or culvert. This, along with photographs, will be sufficient to categorise the most common bridge types encountered on regional and local roads.

If a bridge has substantial extensions of a different type added at one or both ends, the bridge should be recorded as a composite structure with details entered in the comment box and photographs taken of the parts.

Eight bridge types have been included in the BIS look-up menu. 'Others' and 'not surveyed' are also available as an assignment option. 'Not surveyed' should be selected in situations where access difficulties may inhibit initial identification of a structure that is present.

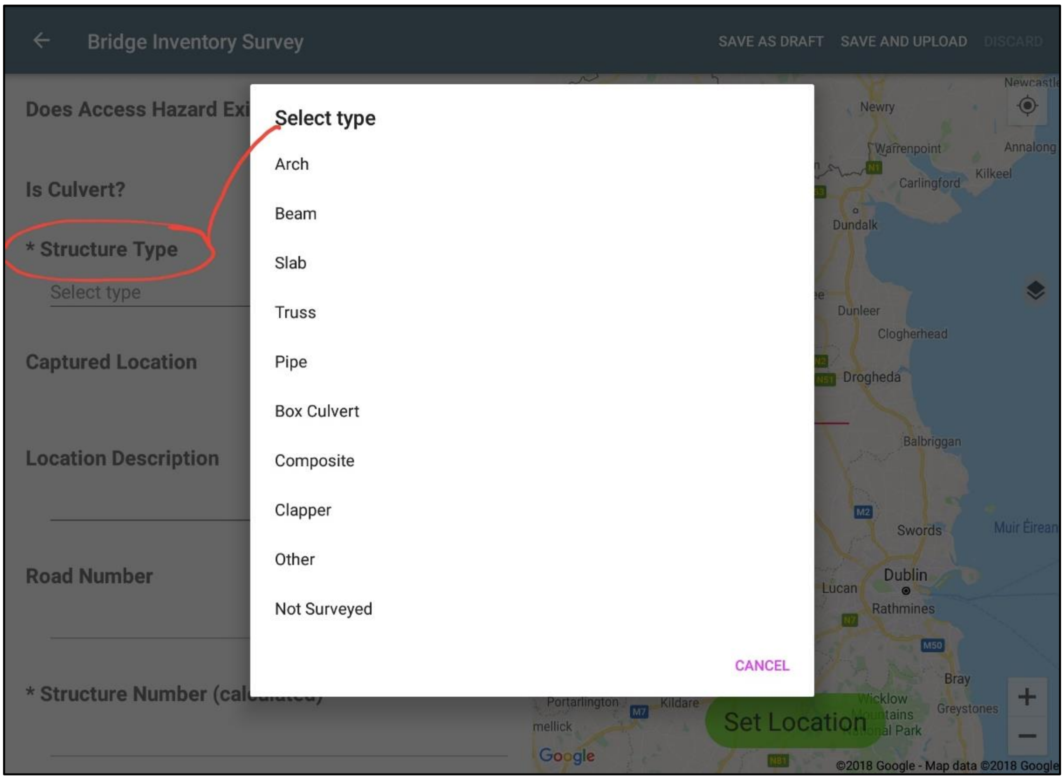


Figure 3.4 – Structure Types

STRUCTURE TYPE		DESCRIPTION
1	Arch	Most common bridges on Irish roads and include any structure with an arch shape E.g. stone arch, brick arch, tied arch, open spandrel arch, precast concrete (e.g. matiere, bebo, flexi-arch) etc.
2	Beam	Any structure where the deck is supported on beams that bear span on to the abutments or piers E.g. Edge beam bridges (including plate girders, box or spine beams) slab / girder.
3	Slab	Any structure where the deck is single slab that bears directly onto the abutments / piers E.g. Generally reinforced concrete.
4	Truss	Mainly steel, iron or timber structures in which the deck is supported on rectangular or triangular trusses e.g. Warren, Pratt, Under-slung, Through, Lattice, usually steel or iron in early periods.
5	Pipe	Any pipe structure e.g. precast concrete, concrete, plastic, ductile/corrugated steel
6	Box culvert	Any other rectangular or square structure E.g. rectangular precast concrete units.
7	Composite	Any structure with more than one form of construction. Bailey bridges (typically, metal truss and timber), metal beams with jack arches. Also, bridges with extensions.
8	Clapper	Single or multi-span stone bridges with stone slabs or stone lintel decks
9	Others	Suspension, cable stayed, moving, portal, bascule, etc.
10	Unsurveyed	This box is ticked where the surveyor can see that a structure exists, but is unable to properly view/identify the structure due to vegetation cover, inaccessibility, etc.

Table 3.1 – Structure Types

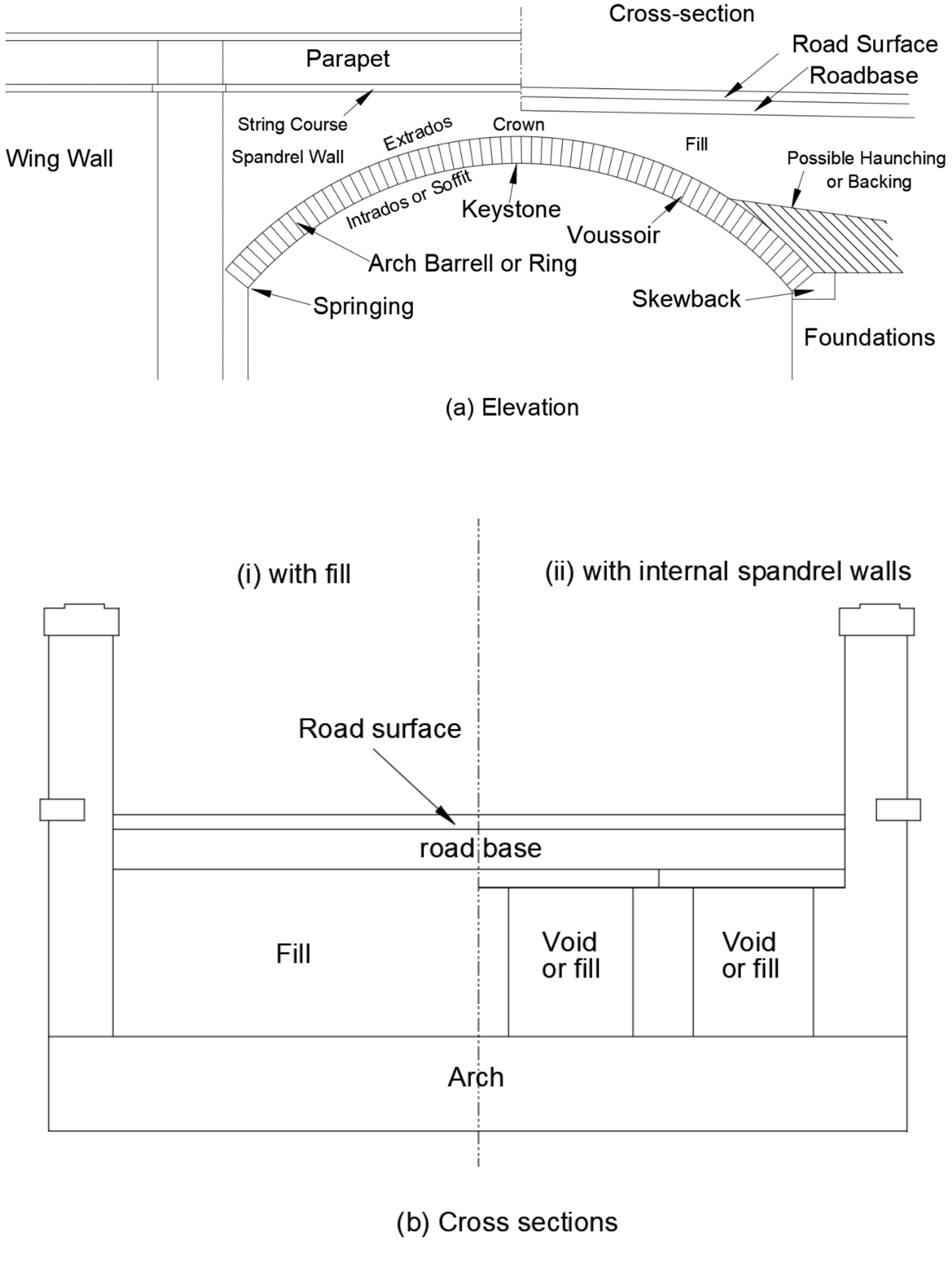
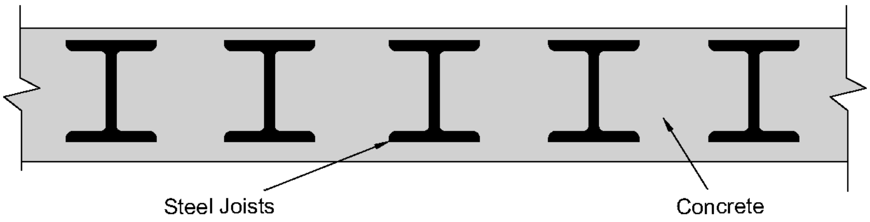
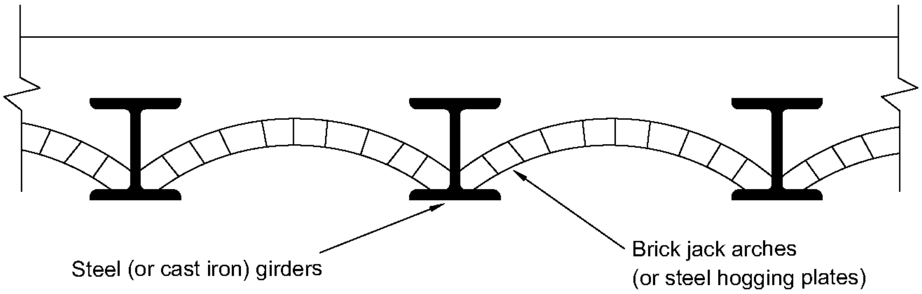


Figure 3.5 – Arch Bridge Nomenclature

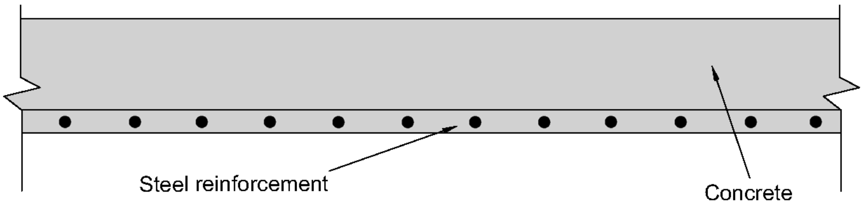
From: TRL State of the art review: Masonry Arch Bridges, Page, J. 1993. HMSO, London



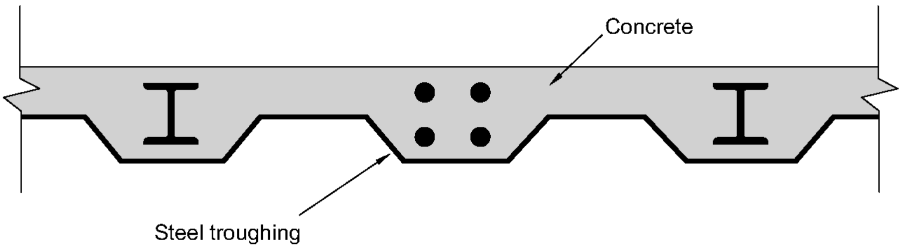
a. Slab



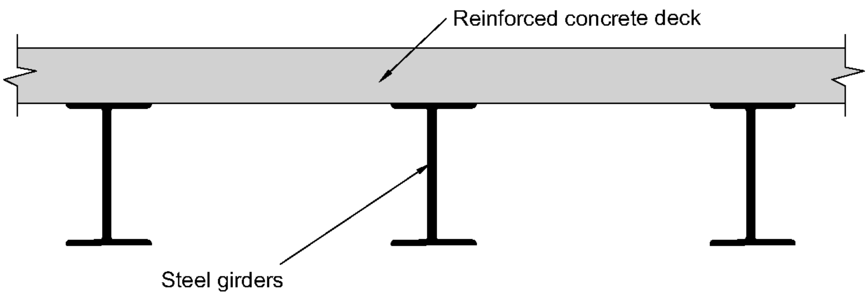
b. Beams with jack arch



c. Typical RC slab



d. Trough unit slab



e. Beams or girder with slab

Figure 3.6 – Typical Simply Supported Bridge Elements

From: Bridge Inspection Guide, DOT, HMSO, UK

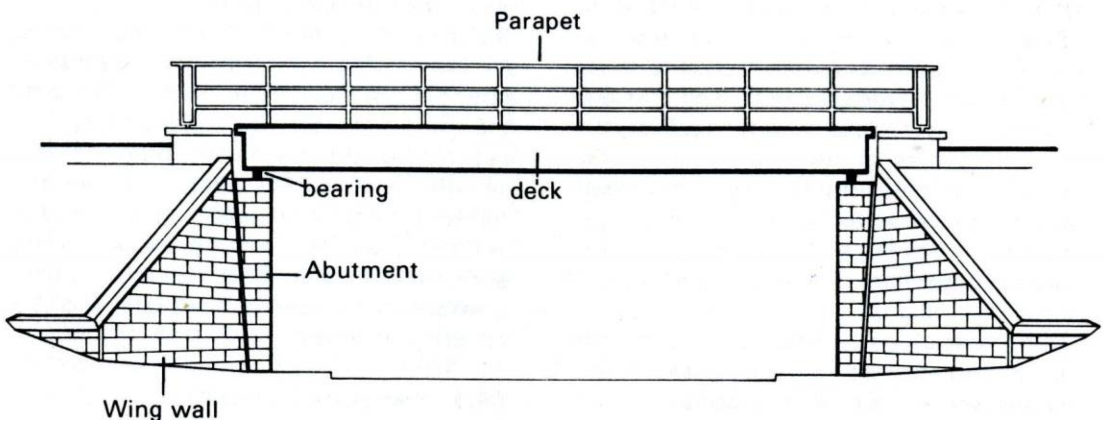


Figure 3.7 – Simply Supported Construction

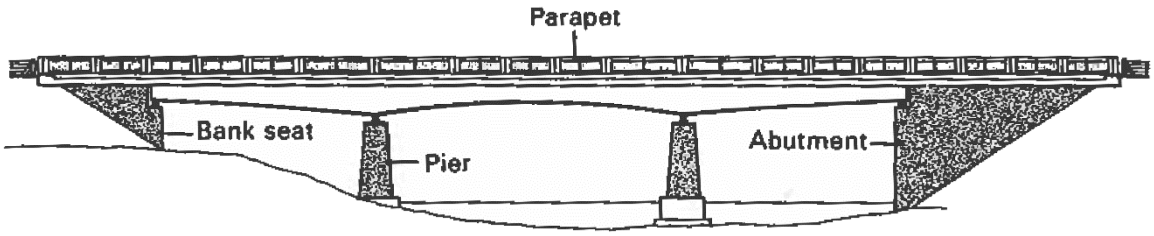


Figure 3.8 – Continuous Construction

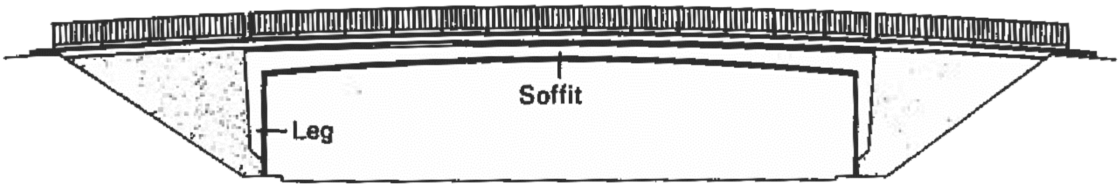


Figure 3.9 – Portal Frame

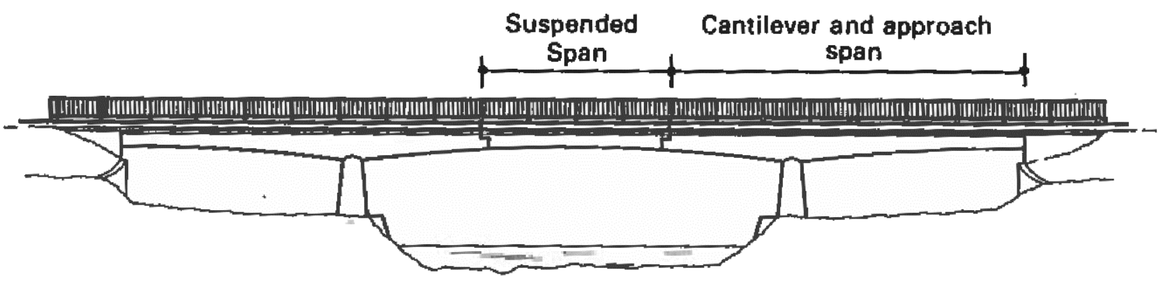


Figure 3.10 – Cantilever and Suspended Span

From: Bridge Inspection Guide, DOT, HMSO, UK

3.6.1 Structure Type Examples

STRUCTURE TYPE	PHOTOGRAPHIC EXAMPLE
Arch	
	Fine limestone single span segmental arch with dressed external voussoirs, semi-circular pilasters coursed abutments and rough tooled coursed spandrels, wing walls and parapets.
	
	Photo shows tooled external voussoirs, random rubble sandstone barrel and spandrel and subsequent replacement limestone coursed parapets with rough repairs and unsightly watermain addition, also inappropriate concrete parapet repairs. River drainage works evidenced by substantial underpinning by OPW works in mid twentieth century

STRUCTURE TYPE	PHOTOGRAPHIC EXAMPLE
Beam	  *Reinforced concrete deep edge beam with transverse beams and slab.*
Slab	 *EG 1. Typical rural concrete slab deck (unknown reinforcement)*

STRUCTURE TYPE	PHOTOGRAPHIC EXAMPLE
	
EG 2. 7m span concrete slab deck in rural area (unknown reinforcement)	
Truss	
Pratt truss – Barrow Bridge, Co. Waterford. (courtesy 'Across Deep Waters', by Michael Barry)	
Pipe	
Corrugated Steel – part view of triple pipe arch (by Asset) with random rubble stone spandrel and parapet façade	

<table>
<tr><th>STRUCTURE TYPE</th><th>PHOTOGRAPHIC EXAMPLE</th></tr>
<tr><td rowspan="2">**Box**

Culvert</td><td></td></tr>
<tr><td>*Rectangular twin box culverts*</td></tr>
<tr><td rowspan="4">**Composite**</td><td></td></tr>
<tr><td>*Typical dubious deck configuration, steel longitudinal beams with concrete infill slabs on rural road.*</td></tr>
<tr><td></td></tr>
<tr><td>*Steel beams with jack arch concrete infill using ‘make shift’ corrugated iron shutters, on masonry abutments. Deck since replaced.*</td></tr>
</table>

STRUCTURE TYPE	PHOTOGRAPHIC EXAMPLE
Clapper Bridge	 
	Smaller more common clapper sandstone bridge
Others	
	Rooskey Bridge – R371 across the Shannon with 'lifting section' (Courtesy 'Ireland's Bridges' by R Cox and M Gould.)

Table 3.2 – Bridge Types – Photographic Examples

3.7 Culverts

For the purpose of this survey, any structure with span equal to or greater than 1.2m (4') or a rise from the river bed to the centre of the arch/soffit greater than 1.2m is considered a bridge.

If both dimensions are less than 1.2m, then the structure is considered a culvert and the inspector should click the culvert box. The user can then enter type, material and a condition. It is important to identify these in the database, not least to eliminate the crossing on the map as being a bridge. Culvert inspections are not necessary for the structures database.

Figure 3.11 – Masonry Clapper

3.8 Structure Material

This is the main construction material or materials within the superstructure (deck) of the bridge. The surveyor will select this from a drop-down menu. On occasion, a structure may be constructed from more than one material.

For example, a bridge may have masonry abutments, steel beams supporting a concrete slab deck. In this instance, the surveyor should select combined and provide details of the construction materials in the general comments text box and photographs. The deck material should be stated. It is the deck material(s) that define the bridge material. The materials shown in the examples below are; masonry, concrete, metal, timber, plastic and combined.

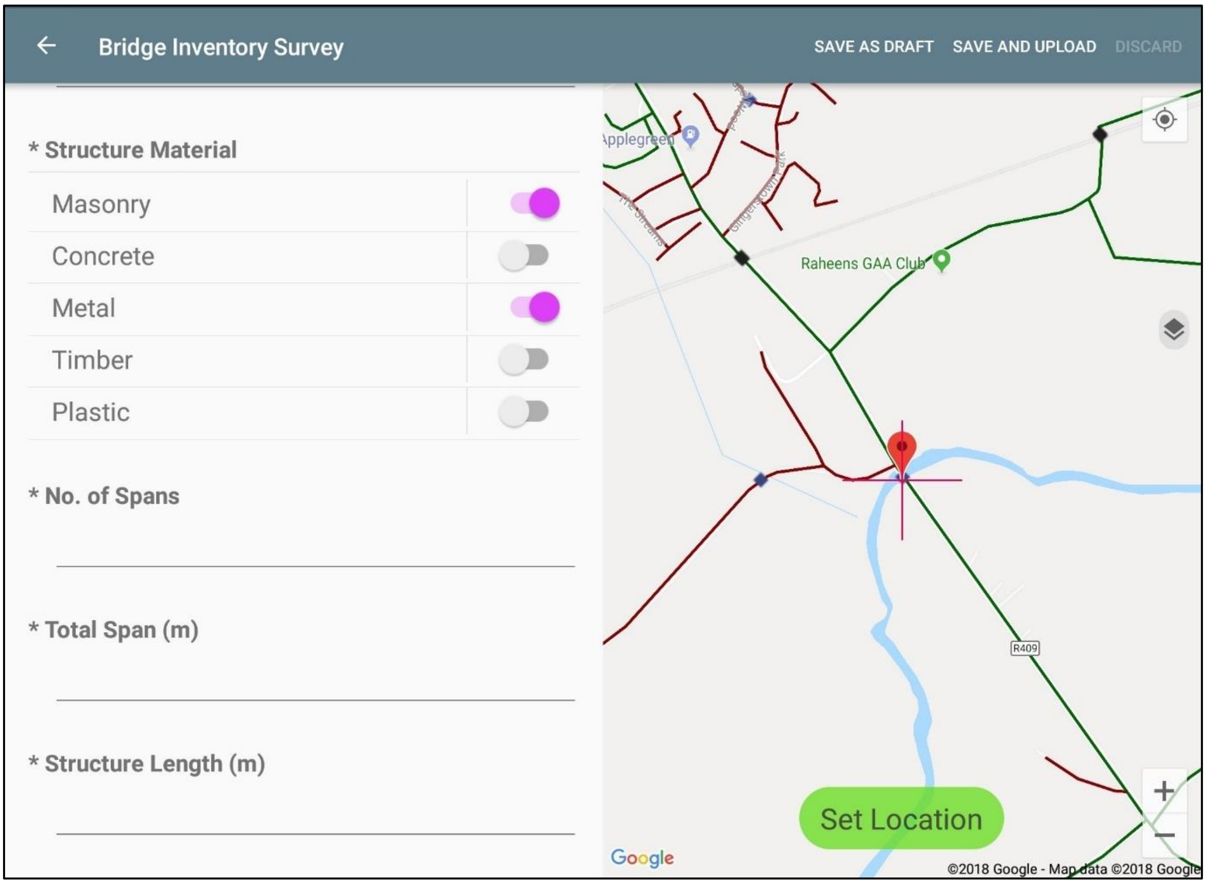


Figure 3.12 – Structure Material

3.8.1 Structure Material Examples

MATERIAL TYPE & PHOTOGRAPHIC EXAMPLE
Masonry This can be brick, cut stone (ashlar) or random rubble stone. Stone is the most common bridge material in Ireland.
 Limestone Ashlar –tight jointed  Red Sandstone, rough coursed, random rubble spandrel infill, with dressed limestone voussoirs.

MATERIAL TYPE & PHOTOGRAPHIC EXAMPLE
Concrete All concrete including reinforced, pre-tensioned, post tensioned and mass.

Prestressed concrete beams.

Precast arch units e.g. Matiere arch system 2no.x 2.2m span

MATERIAL TYPE & PHOTOGRAPHIC EXAMPLE
Metal This includes Steel beams or corrugated pipes, wrought or cast iron.
 *Wrought iron lattice girder 1881*
Timber Any wooden structure.
 *Ekki timber footbridge*

MATERIAL TYPE & PHOTOGRAPHIC EXAMPLE
Plastic Generally large diameter pipes UPVC, HDPE, MDPE etc.

Combined For structures with more than one type of material e.g. steel beams with concrete deck slabs.
 Steel and Concrete

MATERIAL TYPE & PHOTOGRAPHIC EXAMPLE

Steel and Timber

Table 3.3 – Bridge Materials – Photographic Examples

3.9 Number of Spans

Enter the number of spans, most commonly, but not always, an odd number (1,3,5 etc). Where there are ***isolated*** additional flood openings; these should not be included but noted separately as a text comment.

Figure 3.13 – 3 span random rubble medieval stone arch bridge

NB: Interestingly, there is not an arch behind the far cutwater

There is a flood arch on far-left hand side and two stone culverts on the right-hand side, which should **NOT** be included as spans, nor part of the total span, but commented on separately. They would, however, be included within the overall length of the bridge/structure which extends across the entire image. These flood openings should be surveyed as separate culverts. Where there is a dry arch directly adjacent to the river and not far from the other spans this should be counted as a bridge span and part of the total span.

3.10 Structure – Over or Under?

Bridges relating to railway crossings either over or under roads are most likely owned by Iarnród Éireann and are therefore not the responsibility of Local Authorities. They usually have a bridge number plaque, either OB (over bridge) or UB (under bridge), which is an Iarnród Éireann designation. It is important that these bridges are recorded and located, primarily for height restriction purposes, as the Local Authority is obliged to provide optional routes for hauliers with high sided vehicles, but ***these areas should not be entered by surveyors/inspectors***. The Application however will not include bridges associated with railway lines, in the overall Local Authority bridge count.

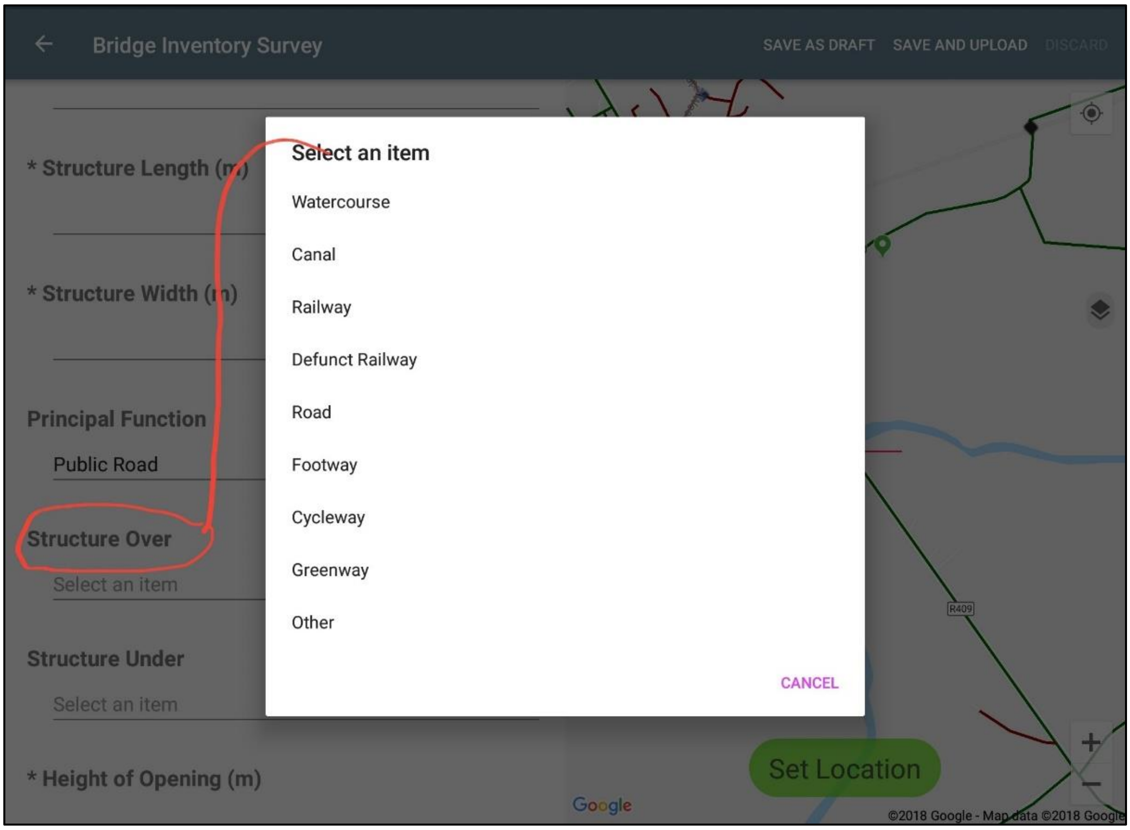


Figure 3.14 – Structure Over Selection

Over	This is a description of what the bridge spans over. The default will be watercourse, but the inspector may select any of the following from a drop-down menu.	Road
		Rail
		Footway / Cycleway
		Canal
		Other
Under	Roads may pass under bridges, particularly under railway lines. This is a description of what the road passes under. The Inspector may select any of the following from a drop-down menu.	Road
		Rail
		Footway / Cycleway - e.g. Abandoned rail lines/greenways
		Canal
		Other

Table 3.4 – Structure – Over or Under

3.11 Structure Dimensions – Recording Basic Dimensions

Many issues have been identified regarding measuring structures for the Bridge Inventory Survey (BIS). 30 out of 33 LA's report having some sort of bridge inventory, perhaps only national and regional road bridges, i.e. a small proportion of their total number, typically less than 20% per county. Different LA's may have different requirements depending on;

- Their current bridge database records
- The number of persons deployed to carry out the BIS
- The time allocation for the survey (e.g. 10-15minutes per bridge etc)
- The photographic capacity and /or viewpoints of a particular structure, from full, easy access of all views, to, on occasion, no elevation view [e.g. due to a steep sided gorge or extensive vegetation blocking views]
- Health and safety concerns, including access or high river levels.

3.11.1 Standard Method

It is recommended that measurements are recorded to **ONE DECIMAL PLACE** of a metre; e.g. 2.4m, 11.7m, 6.0m. Heights over water can be more difficult to measure quickly, however, photographs of a bridge elevation including a ranging rod or staff placed adjacent to the abutment or span will be adequate for providing scale and for the BIS. In addition to the Application, some of the following may be required; a tape (nylon or other), measuring wheel, levelling staff, ranging rod, electronic distance measuring device.

3.11.2 Coarse Method

If the Local Authority does not have a record of how many bridges are in their Administrative Area, or the records are incomplete, and they want to establish a basic inventory of assets, then recording location, type, material and rough size may be sufficient to begin with. In this case, simply ‘pacing’ the spans, bridge length and width etc., may be adequate at road level. The height of the deck or arch can be estimated by eye from the best vantage point. **It this case** it is recommended that only **INTEGER NUMBERS** are entered in the various dimension entry boxes e.g. Total span = 6m, max. span =2m, min span = 1m height of opening =6, etc. It will then be evident to future database users that only coarse ‘paced’ dimensions were input previously. This can be a very quick process.

3.11.3 BIS with follow-up Maintenance Inspection (MI)

If a Local Authority intends to carry out a Maintenance Inspection (MI) immediately after gathering the BIS data, it is recommended that the Standard Method of recording bridge dimensions is used. The inspector must adhere to their Local Authority’s Health and Safety procedures when inspecting the structure and hence be in a position and have the time to take measurements.

NB: More detailed dimensions will be required for structural assessments. Other details will be collected during the Engineering Inspection (EI) regime. However, if time and resources allow, it may be prudent to gather as many detailed dimensions as possible during the course of the BIS and included in the comments box. In this case, input dimensions with **TWO** places; e.g. arch ring depth, concrete beam or slab depth, arch rise at crown and at quarter points which would be included in the comment section as text.

3.11.4 Total Span

The total span of a masonry bridge shall be taken as the distance between the riverside face of the two abutments at the maximum span (note that some masonry bridges have inclined or bellied abutments). If the bridge is skewed, then the skew span shall be used, and the skew angle or square span noted.

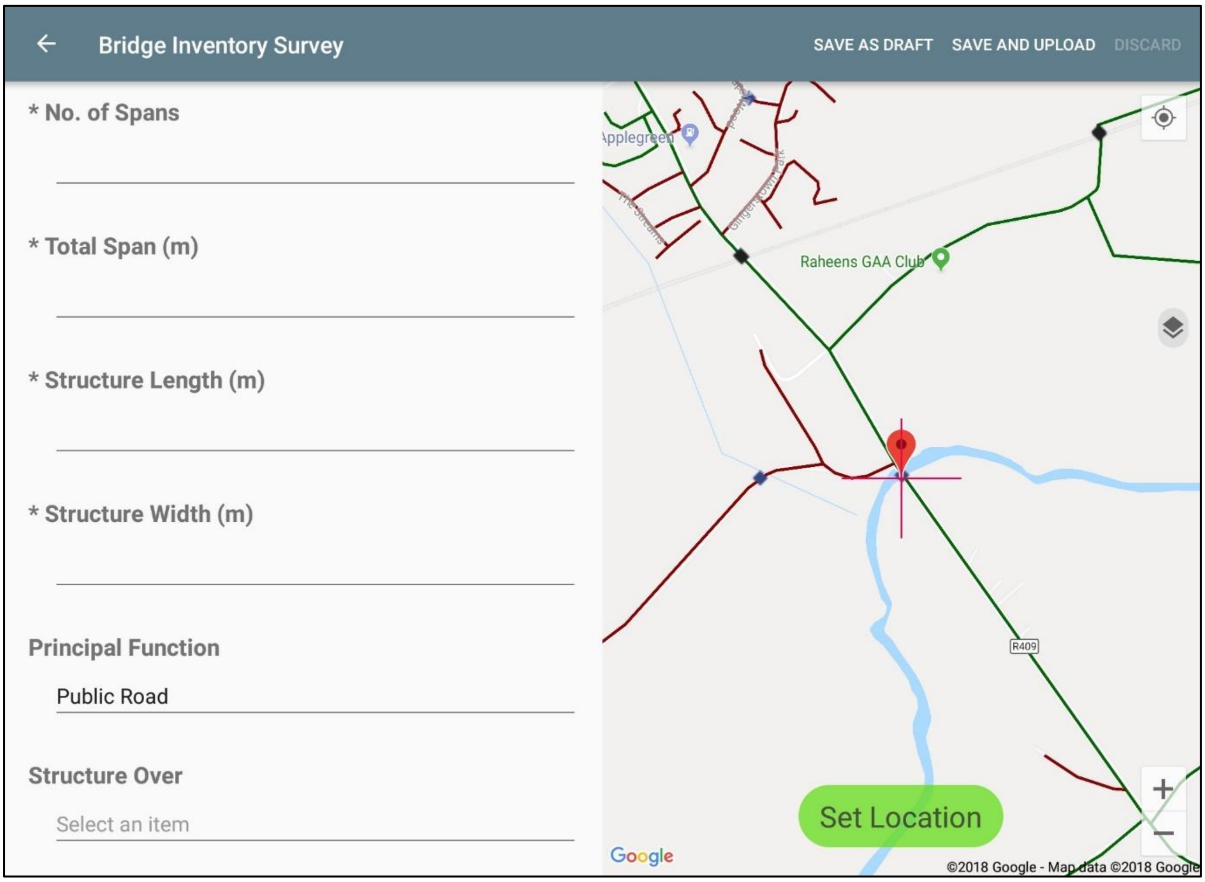


Figure 3.15 – Total Span

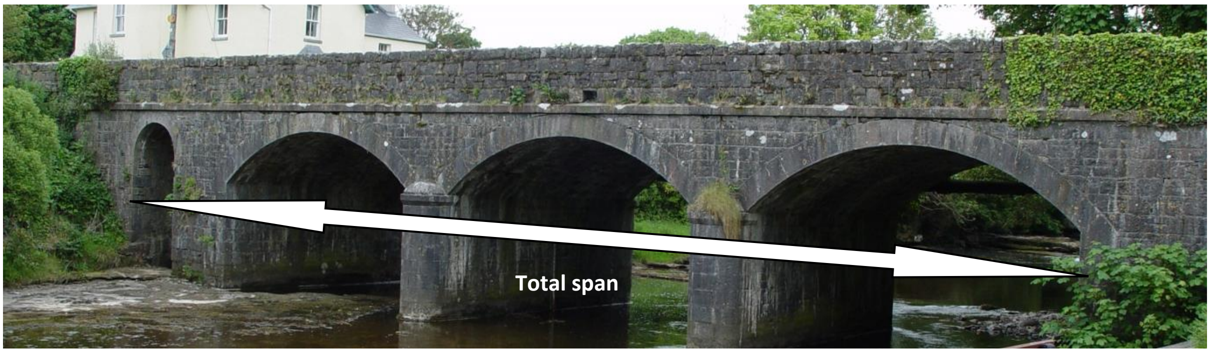


Figure 3.16 – Bridge in Elevation Depicting Total Span

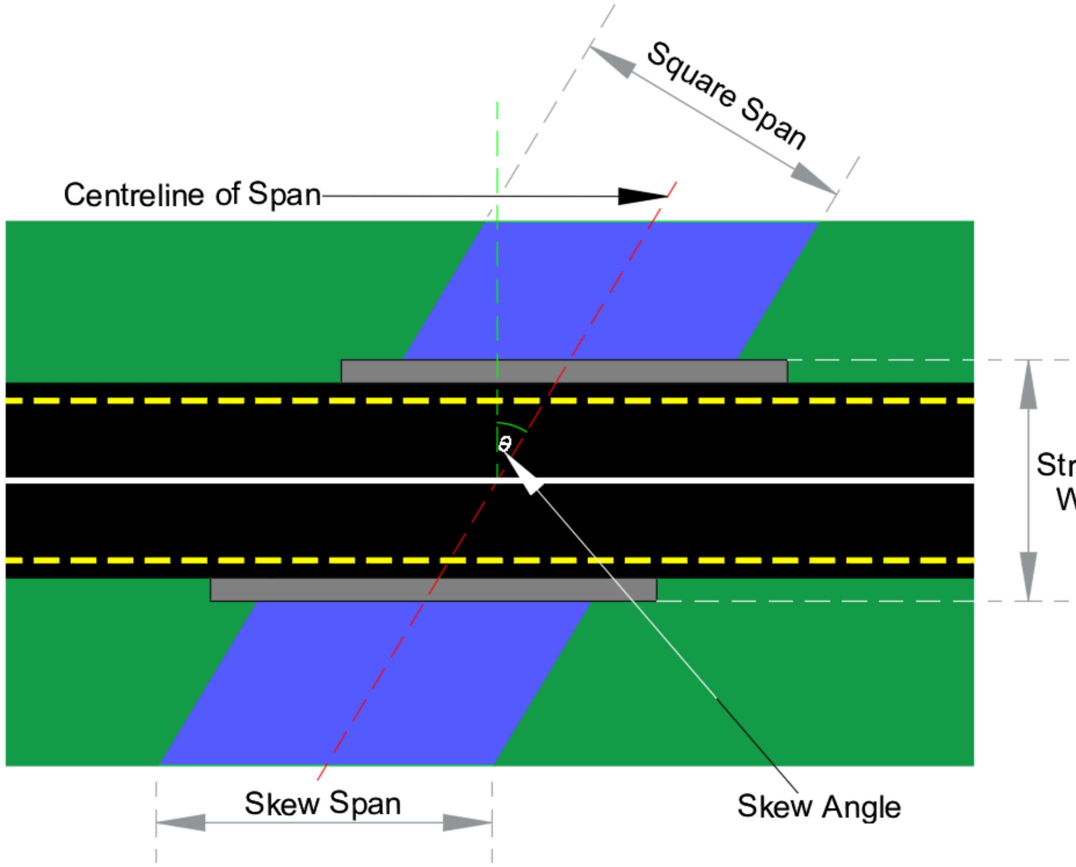


Figure 3.17 – Bridge in Plan Depicting Skew angle and Spans

<u>Maximum / Minimum Span</u>

This field is included (only if No. of Spans >1) to provide a sense of the scale of the structure, to viewers of the bridge inventory, without the need for a full dimension survey.

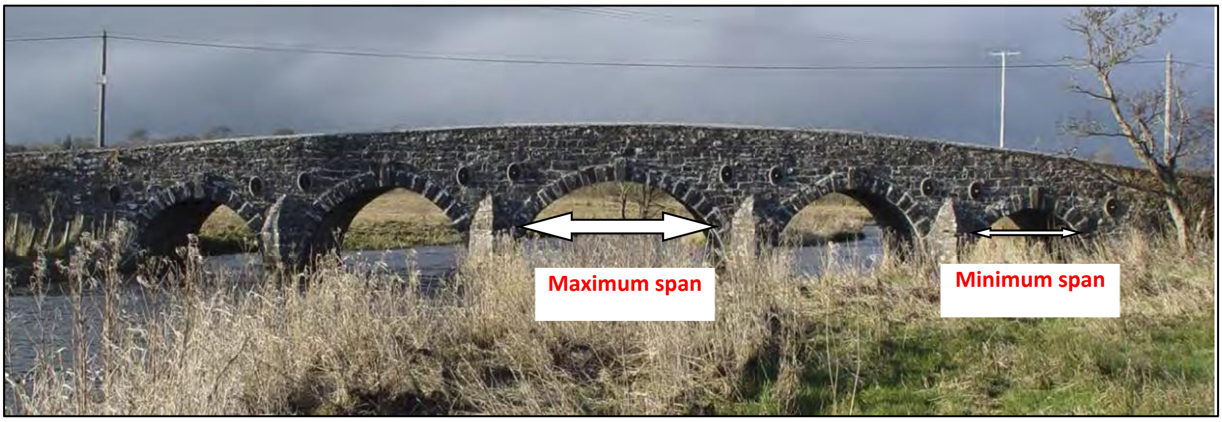


Figure 3.18 – Bridge in Elevation Depicting Max/Min Spans

3.11.5 Overall Bridge Length

Most bridges have a length longer than the total span; be they single or multi-spanned. The overall bridge length including integral wing walls beyond the actual overall span is part of the structure and should be included in this measurement.

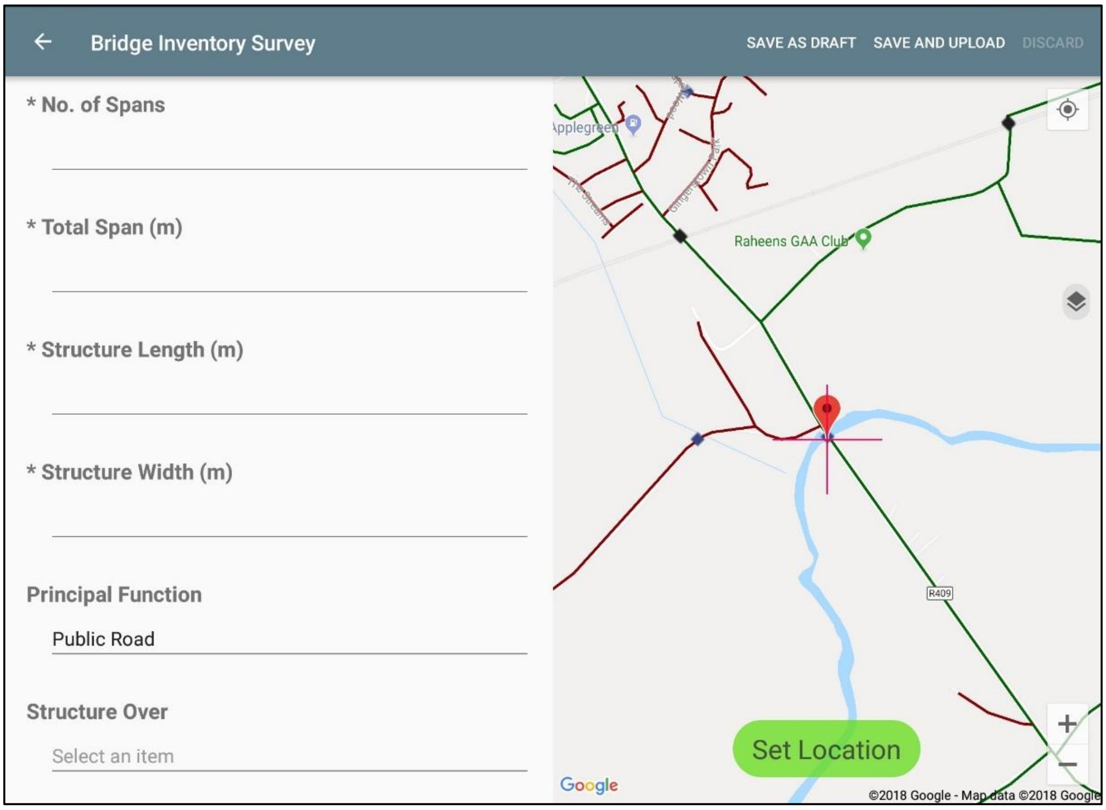


Figure 3.19 – Structure Length

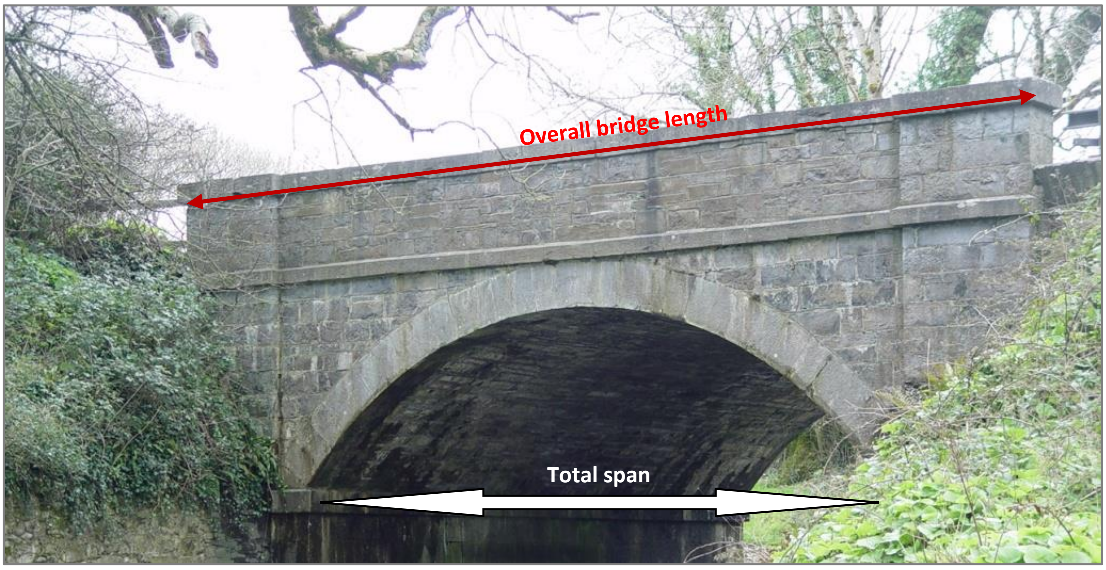


Figure 3.20 – Bridge in Elevation Depicting Overall Length and Total Span

This late eighteenth-century bridge (below) has an **overall bridge length** more than three times the total span. The structure is far bigger than the overall span suggests.

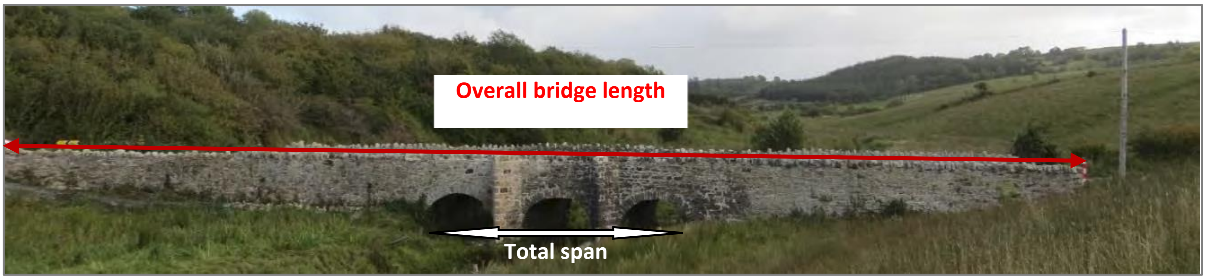


Figure 3.21 – Bridge in Elevation Depicting Overall Bridge Length and Total Span

Where a bridge structure has attached or abutting walling the following shall apply;

1. Where retaining walls are continuous with the bridge abutments, with or without parapets on top, the overall structure length shall include the retaining (wing) walls.

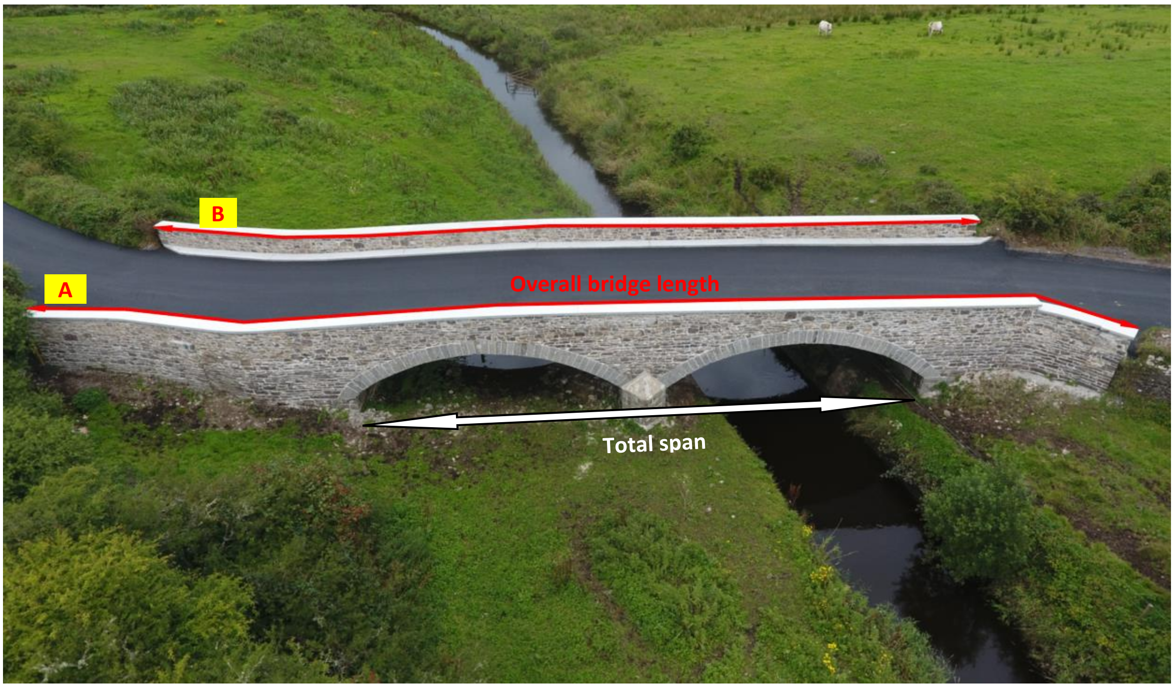


Figure 3.22 – Bridge in Elevation Depicting Overall Length and Total Span

In the above canal bridge example, the overall structure length could strictly be taken as the distance between pediments. However, as the curved wing walls, extending to towards the camera, also support the road (i.e. they are retaining walls) and are continuous with the abutment, they should be included as part of the overall structure length. In this case, the overall bridge length is measurement A, as it is the longest.

2. If a retaining wall extends for a great distance beyond the actual bridge span, e.g. where a road is on a raised embankment or retained embankment, it will be necessary to limit the overall bridge length. In the example below, the near span of the triple arched bridge can be seen to the left, the wing walls are buttressed and the retaining wall curves away from the carriageway, to the corner near the sign (red and white barrier board).

Figure 3.23 – Bridge in Elevation Showing Possible Length of Structure

The image on the right, shows the view looking the opposite way, with the retaining wall then continuing from the corner, to the right some 100m and then off camera for at least another 100m. The surveyor must decide on the extent of the bridge structure and in this case, it is recommended that the overall bridge length structure terminates at the abrupt corner by the sign.

3. Parapets that butt up to the bridge parapets, but which do NOT have a structural/ retaining function shall not be included in the overall length of the bridge structure.

For example, the limestone masonry wall between the nearest two Eircom poles is not a retaining wall, but merely a road side wall and is not part of the 'overall bridge length'

Figure 3.24 – Masonry Wall Not Part of Structure Length

3.11.6 Structure Width

This is the width of the structure, including any extensions, measured in metres (see also Fig. 3.18). On the masonry arch it will generally be the width of the arch. It does not include wing walls or cut waters. This can be measured along the abutment or the pier or from the outside of parapet walls (except where the bridge is skewed) Some structures may have cantilevered sections in which case the inspector should record the longest width and make note of the arrangement in the general comments text box. If the Coarse Method of measurement is being used, the approximate width of the bridge, riverside to riverside of parapets, can be taken at road level.

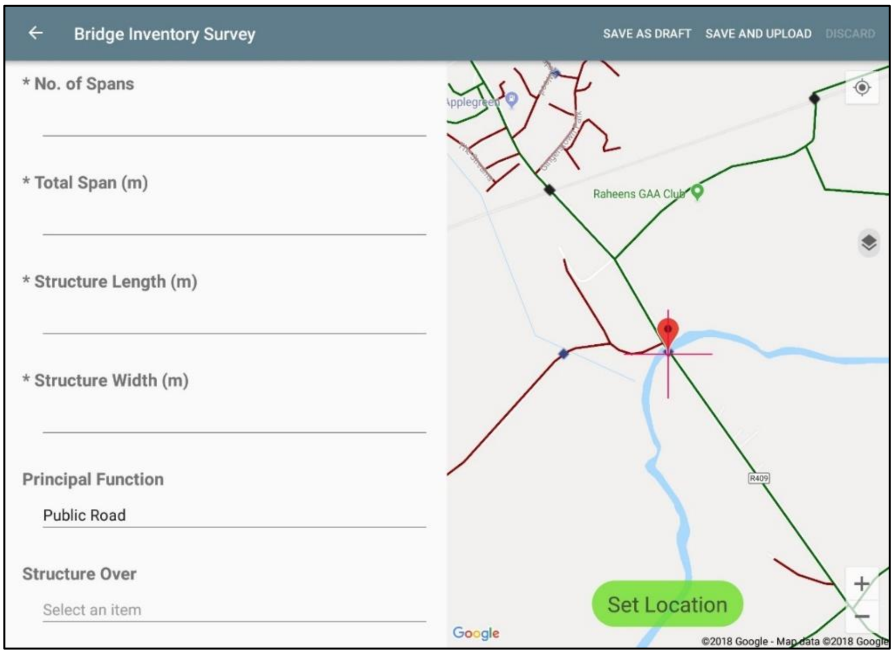


Figure 3.25 – Structure Width

Figure 3.26 – Width of Bridge

3.11.7 Height of Opening and Height and Other Restrictions

This is the height of the opening of the structure as shown below, is measured (or estimated) in metres, is useful for determining whether the structure is a culvert or a bridge and for giving a sense of scale to the structure. This dimension is taken at the midpoint of the span and is measured from the river bed to the soffit. For arches, this will be the bottom of the keystone, for other types of construction this will be the slab or lowest beam. For multi-span structures, the tallest opening is chosen, normally the middle span of the structure carrying the most water. Height of opening is measured in the span carrying the most flow from the river bed to the underside of the keystone. Details of the other spans can be recorded in the comments sections if desired.

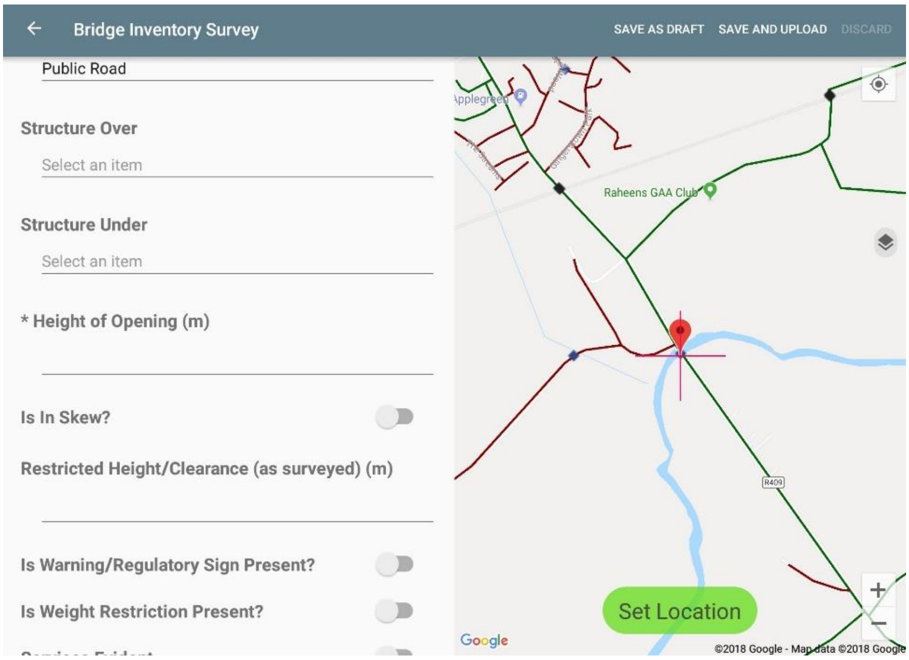


Figure 3.27 – Height of Opening

Figure 3.28 – Height of Opening

Height Restrictions: The dimension recorded is the actual clearance as indicated on the Regulatory sign. The surveyor should verify this measurement during the process. Should the clearance be less than that indicated on the sign, the surveyor shall notify the Municipal District Engineer who will arrange to have the sign replaced.

Figure 3.29 – Height Restriction

Weight Restrictions:

If a weight restriction is in place it should be recorded along with the stated tonnage restriction. If this restriction is known to the inspector and regulatory signage is not in place, the inspector shall notify the Municipal District Engineer who will arrange to have the sign erected.

3.12 Structure at Imminent Risk of Failure

If such a structure is discovered (it will likely be immediately obvious), the surveyor must notify the Engineer in charge who will arrange for an Engineering Inspection (EI) to be carried out immediately. This is one of the most important operations to be carried out by the surveyor/inspector whether they are carrying out a BIS, an MI or an EI. A picture and a description of the fault observed should be taken if it is possible to do so safely.

3.13 Comment Section

There is a general text box available should the user wish to add a comment that is not already covered by the inputs available within the various sections of the Application. The user will be limited to 300 characters and should be used when necessary. It is anticipated that the inputs available within the Application will be sufficient to record the necessary information relating to the structure and will enable those interrogating the bridge stock in MapRoad PMS to filter and generate reports easily, as necessary. Adding a large amount of free text to each structure record may not be of great benefit as it cannot be filtered easily in the PMS system.

3.14 Access and Hazards

HAZARD	RISK
Steep/unstable banks	Potential fall
Deep water	Potential for drowning
Fast moving water	Potential to lose balance or be swept away
Size of structure	very tall, etc
Unstable bed	mud or silt within the stream
Overgrowth / vegetation	Restricts access, can conceal hazards, briars can cause cuts, sticks / branches can lance inspectors
Hazardous species (e.g. Giant hogweed)	Burns and blisters
Fencing	Restricts access, barbed wire can cause cuts, electric fences, impenetrable thorn bushes.
Illegal dumping	Ground may be unstable, potential health hazard
Livestock / pets	Can attack
Traffic	Speed, quantity
Services	Overhead / ducted / buried services may be present
Bridge condition	Risk of falling objects or collapse

The table presents a description of some of the hazards that may be present at the structure that may affect the ability of an inspector to undertake a safe inspection. It is important that access hazards and other hazards are recorded to enable a risk assessment to be carried out.

Table 3.5 – Hazards and Risks

3.15 Photographs

Photographs, a requirement within the Application, are a vital part of the BIS and must be included. It is recommended that 4 identifying photographs are taken and that the first picture taken be an elevation view, this will be the picture that will appear as the default thumbnail for the structure within the MapRoad PMS browser environment.

	**Bridge elevation**, or at least enough to confirm basic bridge type, and material etc. Both up and downstream elevations preferable including differentiating them. [Note this bridge has 5 spans, a photograph from further downstream providing a better elevation/view of the 5th arch would be preferable]. The inclusion of a staff or ranging rod provides a sense of scale where dimensions are lacking.
	**Across bridge along road** – try to pick up a recognisable feature, road surface, verges, parapets and any ponding.
	Down or upstream **view of watercourse** from midspan, preferably both elevations. Capture construction date plaque or other historical markings.
	**Defects**, unusual features, existing widening, access problems, etc. Record as much as possible.

Table 3.6 – Types of photographs

4

MAINTENANCE INSPECTIONS

4 MAINTENANCE INSPECTIONS

4.1 Background

As part of any bridge management system, it is important to know a little about the condition of the bridge and what future maintenance works will be required. Initially, this is recorded in the maintenance inspection tab of the Application. This is not a condition inspection of the bridge just a simple record of the inspector's observations on the day. It is acknowledged that this inspection is limited in nature, that not all elements / defects will be visible and that in most cases the inspector will not be qualified to give an opinion on the structural condition of the bridge. However, any maintenance inspection data collected will immediately be useful and be the primary source of information used to;

- Identify potential problem bridges.
- Prioritise Engineering Inspections.
- Prioritise bridge maintenance and inform improvement works.
- Inform decisions regarding road opening licences, abnormal loads and forestry activities.
- Inform road maintenance and improvement work design.
- Identify potential safety hazards.
- Inform after flooding event inspection.

Following the initial data collection process, it is envisaged that Maintenance Inspections (MI's) will be undertaken on a periodic basis and the data updated accordingly.

4.2 Health and Safety

The Inspector's attention is drawn to Chapter 2 of these Guidelines - Health and Safety. The most important part of any inspection is that it is undertaken safely. The inspector should record only the data that it is safe to collect.

IF IT IS NOT SAFE DON'T DO IT

4.2.1 Access and Hazards

The table below presents a description of some of the hazards that may be present at the structure that may affect the ability of an inspector to undertake a safe inspection. It is important that access hazards and other hazards are recorded to enable a risk assessment to be carried out.

HAZARD	RISK
Steep/unstable banks	Potential fall
Deep water	Potential for drowning
Fast moving water	Potential to lose balance or be swept away
Size of structure	very tall, etc
Unstable bed	mud or silt within the stream
Overgrowth / vegetation	Restricts access, can conceal hazards, briars can cause cuts, sticks / branches can lance inspectors
Hazardous species (e.g. Giant hogweed)	Burns and blisters
Fencing	Restricts access, barbed wire can cause cuts, electric fences, impenetrable thorn bushes.
Illegal dumping	Ground may be unstable, potential health hazard
Livestock / pets	Can attack
Traffic	Speed, quantity
Services	Overhead / ducted / buried services may be present
Bridge condition	Risk of falling objects or collapse

Table 4.1 – Hazards and Risks

4.3 What to Record

The Maintenance Inspection module of the Application is a simple tool used to record data under six headings – Parapets, Access and Egress, Vegetation, External Walls, Abutments and Piers and Deck or Arch.

Each element is given either a **RED** , **AMBER** , **GREEN** or **Not Applicable** rating based on the guidance given in table 4.2 and observations on the day. A general comment box is available for recording additional information about the structure. The inspector must also take photos of any defects observed during the inspection. The photographs will help illustrate the scale of the problem encountered and assist in the prioritisation follow up actions such as engineering inspections or remedial works. A maximum of five photos may be uploaded in the Maintenance Inspection module. Inspectors are encouraged to capture photographs of particular hazards or defects they observe.

NB: Text Boxes / Free Text Entry

A general comment box has been provided to enable the inspector to include more information about the structure. This can be used to record details about any defects found, for example the size and location of a crack or hole. It can also be used to record particular hazards or reasons why element could not be checked, for example deep water or unsafe access.

NB: Dangerous Bridges

There may be occasions where the inspector discovers a bridge that, in their opinion, is an immediate risk to public safety in its current condition. It is essential that each Local Authority has a procedure in place to manage this type of situation to ensure the safety of the travelling public. It is strongly recommended that this be a written procedure with people assigned to particular roles and assigned particular tasks, deputies should also be nominated to deal with normal absences. Each nominated person, including deputies, within the procedure, should be fully aware of their role and the duties assigned to them.

A typical procedure would involve the inspector reporting the structure and the problem to the Municipal District (MD) Engineer for action. A typical response from the MD Engineer would be to check the structure in person to determine the extent of the problem and determine if any immediate temporary measures to make the road safe, such as signing and guarding, are required.

The MD Engineer may then wish to seek the opinion of the Local Authority bridge engineer (or Engineer in charge of bridges) if the problem is a complex one or the MD Engineer may be able to address with the matter personally depending on their experience and competence. Guidance on how to rate defects of different bridge/structure elements is given in the table below with further photographic examples provided on subsequent pages.

4.4 The Rating System

The RED , AMBER , GREEN rating system is used to categorise the observed condition of each element of the bridge and is summarised below and tabulated in table 4.2;

- The RED rating indicates that the structure has serious defects present which left uncheck could result in the failure of the element (if it has not already failed)
- The AMBER rating indicates that there are defects present within the element which require repair but are not yet critical. Therefore the element is in moderate condition.
- The GREEN rating indicates that the element is generally in good condition and functioning as intended.
- Not Applicable is used to record an element that was not safe to inspect, that the inspector could not see or was not present. It is helpful to record reasons in the comment text box.

The application, when all six elements have been assigned a rating, calculates the overall Maintenance Rating of the bridge automatically based on the structural elements only. The bridge will receive a rating of RED , AMBER or GREEN within the MapRoad PMS system, users can then filter bridges based on this basic rating to focus their attention and prioritise which bridges require an Engineering Inspection.

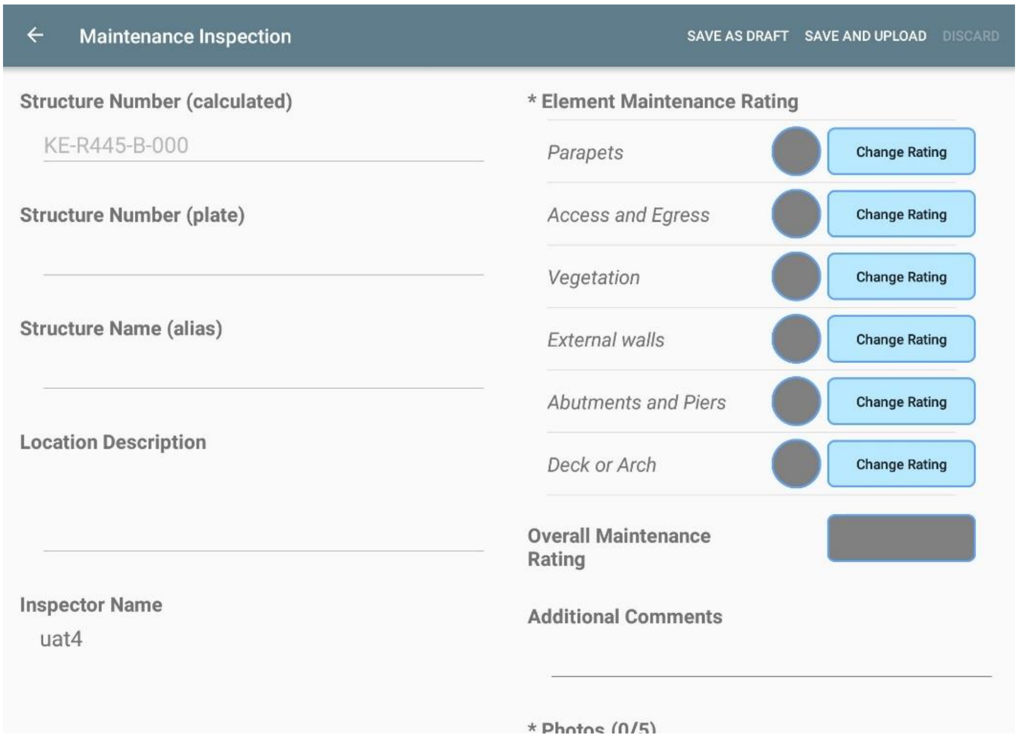


Figure 4.1 - Maintenance Inspection Screen

Main Element	RED	AMBER	GREEN	NOT APPLICABLE	
Parapets	Part or all of parapet or safety rail missing, collapsed or significantly displaced.	Some damage - nuts missing, corrosion, deformation, cracking, vegetation causing disturbance, tilting, sliding, missing masonry.	Minor defects or vegetation growth only.	**Select this if it is obvious the Structure never had a parapet.** If unsure, please select **RED**	Non-structural
Access and Egress	Dangerous high risk ***DO NOT ENTER***	Some hazards and risk. Risk assessment required.	Easy and safe.		
Vegetation	Heavy growth and/or Invasive species.	Appreciable growth clearance required, includes some Ivy, small saplings, brambles.	None or minor growth only.		
External walls	Significant cracks, bulging, leaning, rotation, missing masonry, or a collapse. Significant exposed reinforcement and/or corrosion.	Some cracks, bulging, leaning, rotation, minor missing masonry, exposed reinforcement, corrosion.	No evidence of or minor defects present.	Structure doesn't have external walls Or Couldn't access.	Structural
Abutments and Piers	Severe scour holes below walls, Significant areas of missing masonry or failure. Significant rusting of steel members, buckling or steel missing.	Some scour in bed, pier or abutment. cracks, leaning, bulging, missing stones, exposed reinforcement, or rusting of steel members.	Minor or no evidence of scour in bed. Minor or no evidence of defects in pier or abutment.	Couldn't access.	
Deck or Arch	Large cracks, severe sagging, spalling, deformation, missing elements, arch separation. Severely exposed reinforcement, corroded or missing steel on struts, ties, beams or failure. Holes.	Some: cracks, sagging, spalling, missing elements, exposed rebar or rusting of steel, struts, ties, beams or corrugated or other jack arch elements.	None or minor cracks, sagging, spalling, or any other minor defect.	Couldn't access.	
Overall Rating determined by worst rating of the three structural components					

Table 4.2 – Maintenance Inspection Rating Guide

4.4.1 Parapets

The inspection begins from the road with a check on the parapets and any damage which may be observed on the day. The function of a parapet is to prevent errant vehicles or pedestrians from falling into the watercourse. Therefore, damage is an important safety issue and should be recorded.

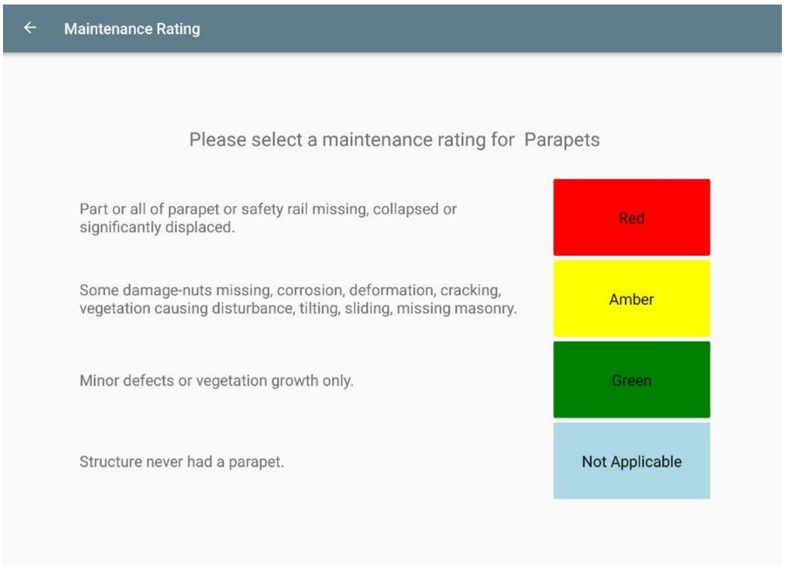


Figure 4.2 - Maintenance Inspection – Parapets Rating Selection Screen

4.4.2 Access and Egress

The Inspector then considers the hazards associated with accessing the structure, to ensure it is safe to proceed with the inspection. Where it is deemed unsafe, it is important to record the reasons in the available text box to inform and advise future inspectors of potential hazards.

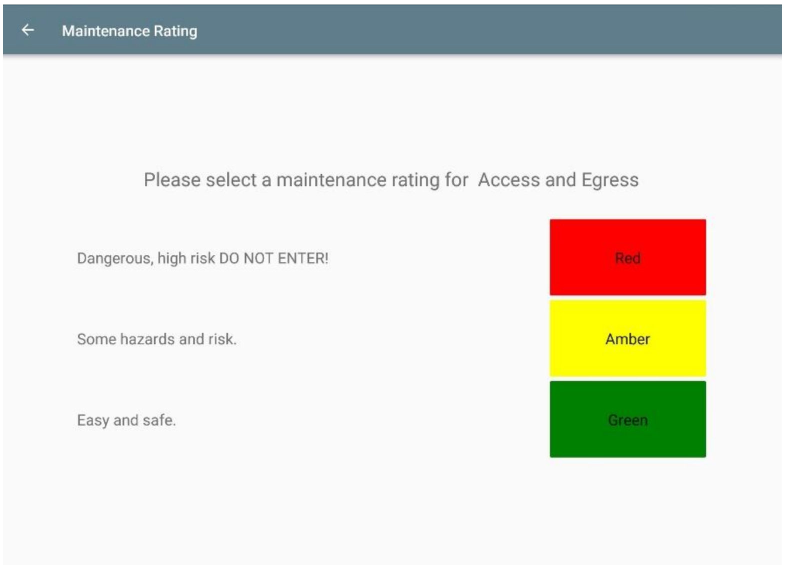


Figure 4.3 - Maintenance Inspection – Access and Egress Rating Selection Screen

4.4.3 Vegetation

Vegetation can restrict the Inspector's ability to safely undertake the full bridge maintenance inspection and left unchecked the vegetation can cause significant damage to the bridge itself. This information will be particularly useful in organising programmes of vegetation removal and preventative maintenance works. The presence of Giant Hogweed or Japanese Knotweed should be recorded in the comment box.

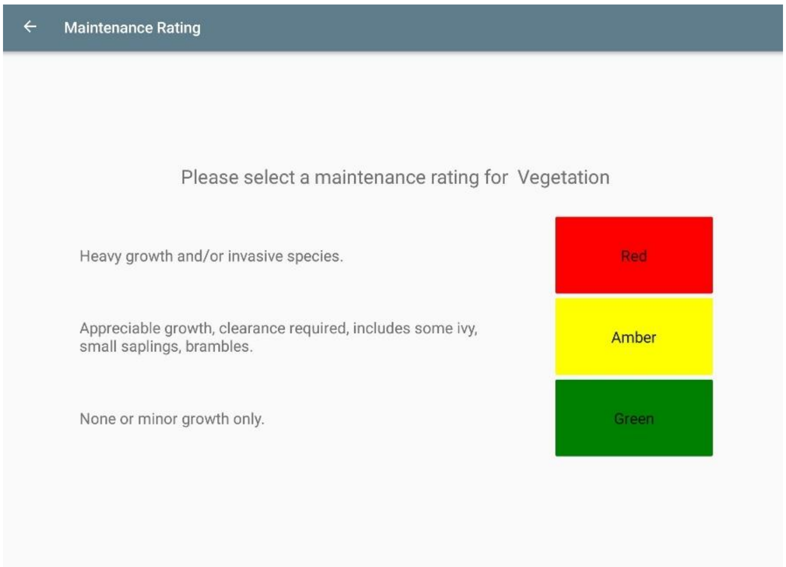


Figure 4.4 - Maintenance Inspection – Vegetation Rating Selection Screen

4.4.4 External Walls

This is a check of the walls below the parapets on the outside of the structure, namely the spandrels, wing walls and buttresses. Common defects include missing masonry, cracks, bulges, leaning or rotating walls and collapses, seperation between wall and footpath/verge/surfacing.

These are structural elements and their failure could lead to the overall failure of the bridge.

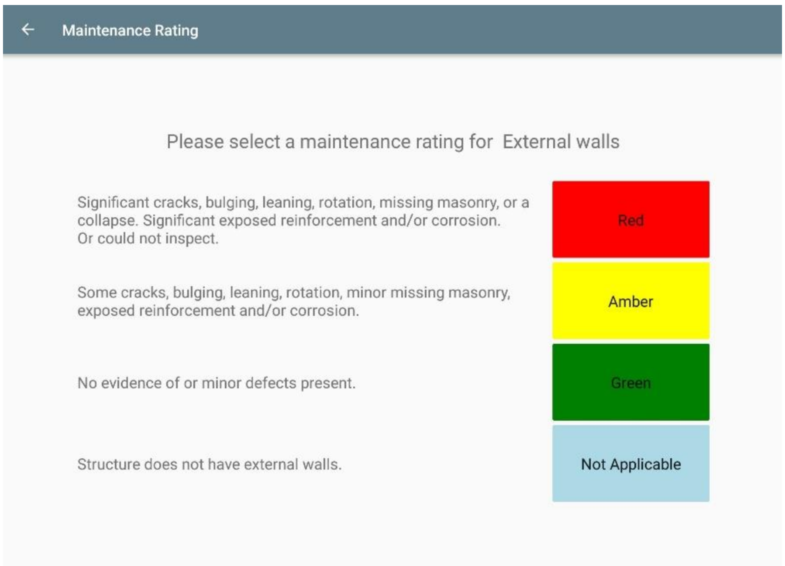


Figure 4.5 - Maintenance Inspection – External Walls Rating Selection Screen

4.4.5 Abutments and Piers (including riverbed and foundations)

This is a check of the supporting walls under the bridge deck or arch. Common defects include missing masonry, cracks, exposed reinforcement, corroded reinforcement, bulges, leaning walls, scour holes and collapses, trees/debris lodged in eye of bridge. Again these are structural elements and their failure could lead to the overall failure of the bridge. Scour should be investigated at low flow or tide, bridges fitted across openings can cause scour. If not possible at time of inspection, the necessity to check for scour should be recorded in the comment box.

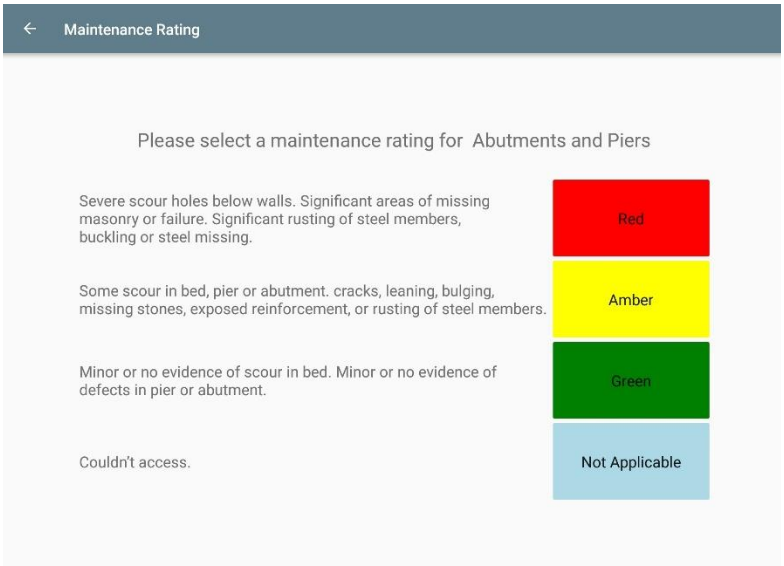


Figure 4.6 - Maintenance Inspection –Abutments and Piers Rating Selection Screen

4.4.6 Deck or Arch

This is a check of the arch or deck of the bridge including any supporting beams or truss. Common defects include missing masonry, cracks, permanent deformations, arch ring separation, exposed steel works, corroded or missing steelwork, percolation, holes and collapses. Again, this is a structural element of the bridge, failure could lead to catastrophic failure of the structure.

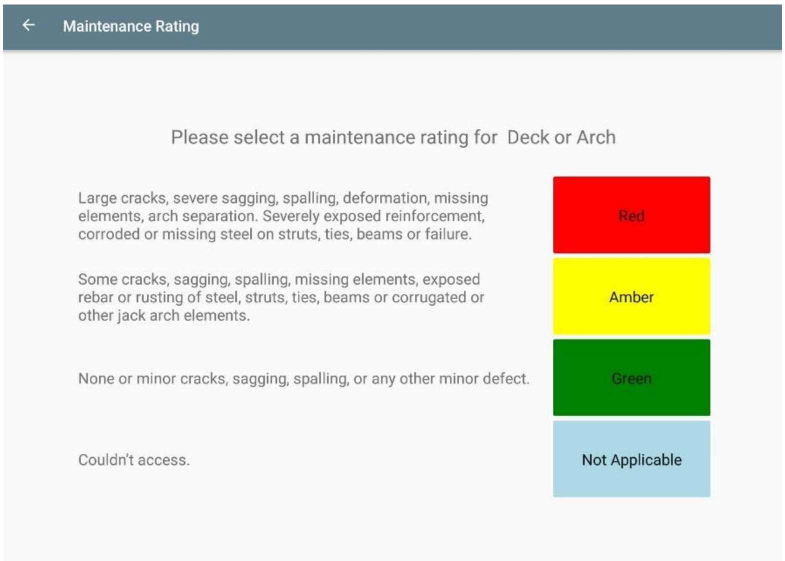


Figure 4.7 - Maintenance Inspection – Deck or Arch Rating Selection Screen

4.5 Rating System Examples

PARAPETS	**NS**
RED Parapet has significant damage that represents a safety hazard. In the **<u>example</u>**, the parapet is completely missing from this bridge and is now a safety hazard.	
AMBER parapet has defects and requires repair but is still functional. **<u>Example 1</u>**: the parapet has been damaged but is still in place and operating albeit to a lesser standard. Repair work is required. **<u>Example 2</u>**: the parapet which was already low is missing a row of coping stones and requires repair.	 

PARAPETS	NS
GREEN Parapet is in good condition and will function as designed. In both **examples**, there is no damage and both parapets are performing as designed. The Parapet in example 2 may be slightly low for full pedestrian protection, however, it is as built, so this will not affect the condition rating.	 
Not Applicable Parapet was never present. In this **example**, there is limited cover above the clapper bridge and parapets were never provided on this bridge.	

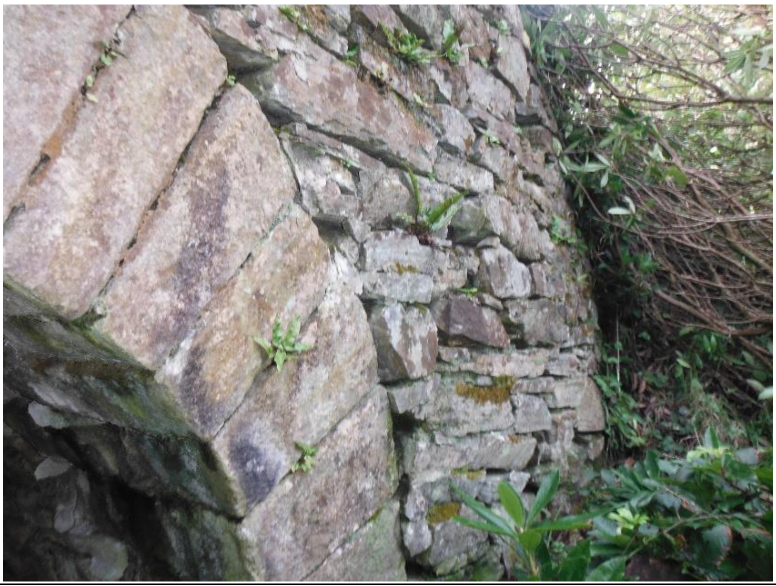
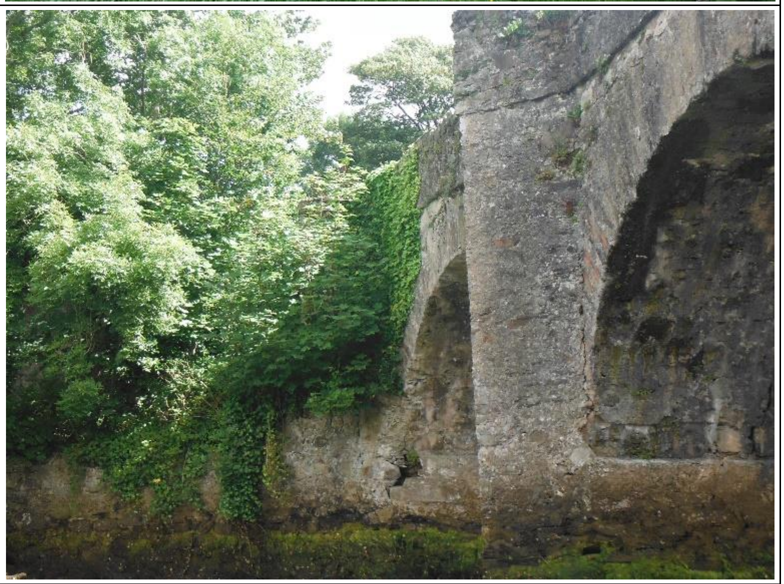
ACCESS AND EGRESS	NS
RED access is high risk and dangerous. **<u>Example 1</u>**: high sided walls, water is deep and fast flowing in areas, steep level changes and potentially slippery rocks. Specialist access equipment is required so access should not be attempted. However, record reasoning for future inspectors.	
<u>Example 2</u>: bridge is built on a rock outcrop at a height with sloped slippery surfaces. Specialist access equipment is required so access should not be attempted. However, record reasoning for future inspectors.	
<u>Example 3</u>: deep coloured water present. Access is not possible. Record reason for future inspectors. **NB:** Returning to a bridge site when river levels are low may provide stream bed access and reduce both hazards and risks	

ACCESS AND EGRESS	NS
AMBER some hazards and risk. **Example 1**: the banks are high near the bridge, there is also fencing and some overgrowth. Access may be possible by entering the watercourse downs stream and walking along the stream. Site Specific risk assessment required.	
Example 2: road verges are steep with a slippage. The bank is above the stream and almost vertical but low. There is a build-up of debris in the stream and the bed appears boggy. Access may not be possible in this instance. Carry out site specific risk assessment and if access is not possible record the reasons why.	
GREEN easy and safe. In this **example**, there is easy entry to the banks via the gate, the banks are sloped gently, and the water is shallow and slow flowing.	

VEGETATION	NS
RED heavy growth. **Example 1**: a tree has been allowed to grow on this bridge, the roots have which have damaged the structure by displacing stones in the arch ring.	
Example 2: heavy ivy growth present on this structure. This will damage the structure by displacing pointing and masonry and allowing water ingress into the structure.	
Example 3: heavy growth on the banks and walls of this structure restricts access. Removal is required to facilitate inspection. Record details within the APP.	

VEGETATION	NS
AMBER appreciable growth on the structure, clearance required. **<u>Example 1</u>**: some ivy present and trees have become established. If left unchecked, they will damage the structure. Vegetation removal is required. **<u>Example 2</u>**: Ivy is becoming established on the structure and obstructs the view of that element. If left unchecked it will begin to damage the structure, therefore removal is required.	 
GREEN no growth or minor growth only. in this **<u>example</u>**, there are a few minor grasses growing on the structure.	

EXTERNAL WALLS	S
RED significant damage. **<u>Example 1</u>**: the wing wall collapsed. **<u>Example 2</u>**: the arch ring, part of the spandrel and the wing wall has collapsed.	 
AMBER some defects present requiring remedial works. **<u>Example 1</u>**: a large crack has formed on the wing wall as a result of movement. Note a tell-tale has been used to monitor the crack progression. Monitoring is required	

EXTERNAL WALLS		S
Example 2: the wing wall has lost its pointing and is bulging at the base. Repairs are required.		
GREEN No defects or minor defects present. In this **example**, the external walls are in good condition with no bulges of cracks. It is generally well pointed with only minor areas require remedial works.		
Not Applicable element not visible or provided. In this **example**, the wing walls and part of the spandrel on the opposite side of the bridge are not visible due to vegetation.		

ABUTMENTS AND PIERS	S
RED severe defects and damage. **Example 1**: large hole in abutment.	
Example 2: central pier has been undermined by scour.	
AMBER some scour or defects present in the walls. **Example 1**: small area of scour beneath an abutment. If left unchecked there is the potential for further masonry loss and the undermining of the structure. Repair work is now required.	

<table>
<tr><th colspan="2">ABUTMENTS AND PIERS</th><th>S</th></tr>
<tr><td><u>Example 2</u>: there is a loss of pointing and small areas of masonry loss. If left unchecked the structure will deteriorate and create a significant defect. Repair work is now required.</td><td colspan="2"></td></tr>
<tr><td>GREEN

no damage or minor damage only.

In this <u>example</u>, the masonry and most of the pointing is in place. There has been some movement of the bed material, but this is not yet significant.</td><td colspan="2"></td></tr>
<tr><td>Not Applicable

unable to inspect element.

In this <u>example</u> access to the steel culvert is restricted by high water.</td><td colspan="2"></td></tr>
</table>

DECK OR ARCH	S
RED significant defects present. **<u>Example 1</u>**: hole in soffit masonry caused by poorly installed service.	
<u>Example 2</u>: The external arch ring is detaching from arch barrel and has now opened up a significant void.	
<u>Example 3</u>: dropped stones and permanent deformation on the soffit of this arch barrel.	

<table>
<tr><th colspan="2">SOFFIT / DECK</th><th>S</th></tr>
<tr><td>RED

significant defects present.

<u>Example 4</u>: concrete has spalled from deck exposing rebar reinforcement which is corroding and losing effectiveness.</td><td colspan="2"></td></tr>
<tr><td><u>Example 5</u>: steel beams within deck are exposed and corroding. Tie bars have also corroded and sheared.</td><td colspan="2"></td></tr>
<tr><td>AMBER

some defects present.

<u>Example 1</u>: soffit has completely lost its mortar and cracks are beginning to form. If left unchecked the masonry will begin to move and may be lost. Repair work is now required.</td><td colspan="2"></td></tr>
</table>

DECK OR ARCH	S
<u>Example 2</u>: the concrete encasing the steel beams is beginning to crack, there is staining present indicating corrosion of the beams. Stalactites are visible on the beams indicating water ingress through percolation within the structure. Further investigations and repair works are now required.	
GREEN no defects or minor defects present. In this **<u>example</u>**, the soffit is well pointed and retains its shape.	
Not Applicable unable to inspect element. In this **<u>example</u>** water levels are too high to gain access and the deck is not visible from the banks.	

Table 4.3 – Rating System Examples

5

ENGINEERING INSPECTIONS

5 ENGINEERING INSPECTIONS

5.1 Introduction

Engineering Inspections (EI) shall be undertaken by Local Authority engineers at Executive Engineer level or above who have significant bridge experience and who have undertaken appropriate bridge related training. Preferably, they will be Chartered Engineers. This Engineering Inspection will assign a condition (CR) rating to the structure. The bridge location and bridge number will have been established in the Bridge Inventory Survey (BIS) (Chapter 3) and possibly the bridge name established from non-site information (Chapter 6). If not, newly found bridges can be added by going back to the BIS and inputting the basic data there first. The Engineering Inspection (EI) is designed to be used with a tablet Application, similar to the Pavement Surface Condition Index (PSCI). The inspection requires access to the river banks and under the soffit of the bridge, appropriate risk assessment and PPE and precautions must be taken (Chapter 2). The table below presents a description of some of the hazards that may be present at the structure that may affect the ability of an inspector to undertake a safe inspection. It is important that access hazards and other hazards are recorded to enable a risk assessment to be carried out (these will likely already be identified during the MI).

HAZARD	RISK
Steep/unstable banks	Potential fall
Deep water	Potential for drowning
Fast moving water	Potential to lose balance or be swept away
Size of structure	very tall, etc
Unstable bed	mud or silt within the stream
Overgrowth / vegetation	Restricts access, can conceal hazards, briars can cause cuts, sticks / branches can lance inspectors
Hazardous species (e.g. Giant hogweed)	Burns and blisters
Fencing	Restricts access, barbed wire can cause cuts, electric fences, impenetrable thorn bushes.
Illegal dumping	Ground may be unstable, needles, Weil's disease, potential health hazards
Livestock / pets	Can attack
Traffic	Speed, quantity
Services	Overhead / ducted / buried services may be present
Bridge condition	Risk of falling objects or collapse

Table 5.1 – Hazards and Risks

This Engineering Inspection is essentially a visual inspection but some prodding and tapping may also be useful. The Engineer, however, may wish to take some measurements which are not compulsory at BIS stage to aid understanding and in assessing a particular structure's capacity, e.g. beam or slab depth, arch thickness at crow, cover, arch rise at crown and quarter points. Such additions can be included in the comment box. An element by element inspection is required and a rating is to be assigned to each element, the component Condition Rating (cCR). The overall Condition Rating (CR) is manually entered by the inspector.

The CR is based on the ratings of the structural elements only. Photographic evidence of the defect(s) must be collected. Up to 30 photographs can be collected in the Engineering Inspection module of the app and stored on the MapRoad system.

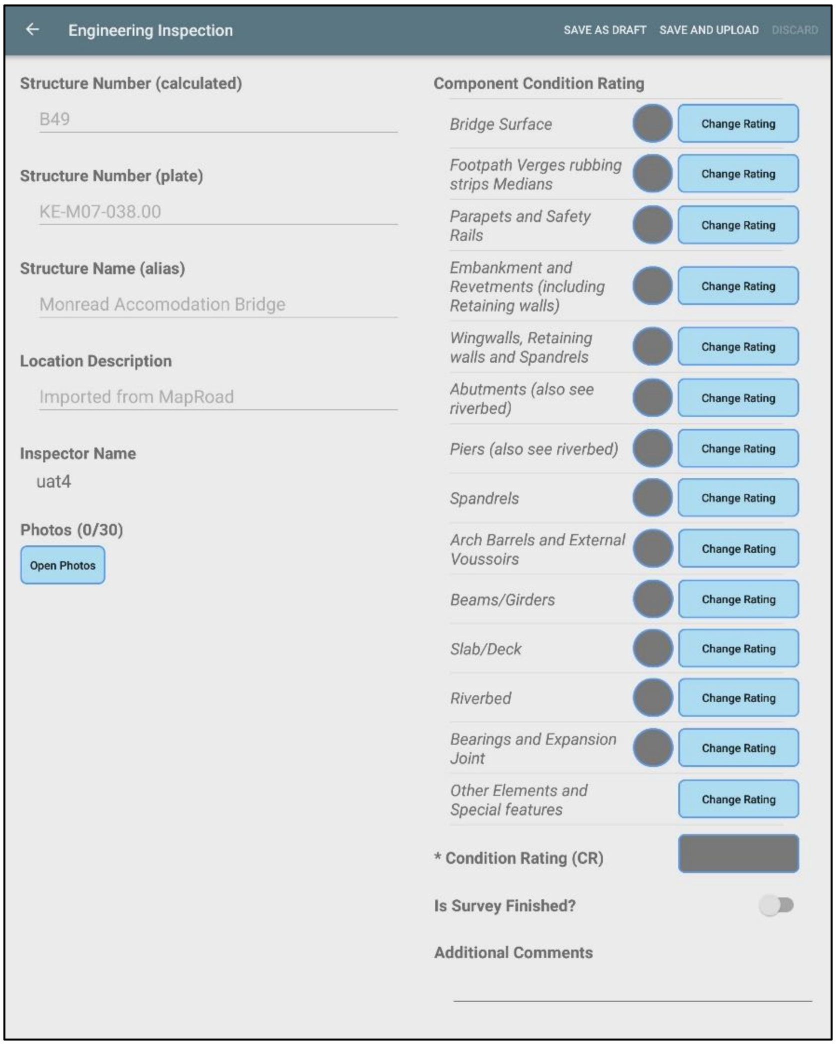


Figure 5.1 - Engineering Inspection Screen

Text examples hereunder show possible inputs/selections and will be dependent on the Inspectors' local knowledge, historic references, the detail of previous information already stored and emphasise the status of the structure. Some Local Authorities may already have a bridge database established but will be adding to it over time. The overall condition rating of the bridge is related to the structural elements only. Photographic evidence of the defect(s) of concern and brief note of the defects should be entered in the comment box.

5.2 Condition Rating of Bridge Components (and the bridge)

The Engineer assesses the condition of the 14 components listed in the table beginning on page 84. Components are classified as either structural or non- structural. The Engineer must enter a rating for each component. When each component has been rated the overall rating of the structure is assigned by the inspector. This will normally be the highest rating of all the structural components but may be greater due to the cumulative effect of a number of defective structural elements. Examples are provided on page 73 and guidance is provided in the table beginning on page 84.

CONDITION RATING (CR) – GIVE RATING FROM ONE OF THESE CONDITIONS			
RATING	**LEVEL OF DAMAGE**	**WORKS REQUIRED**	**WHEN**
1	Insignificant damage	Minimal work required	non-critical
2	Some damage	Minor repair work required	repair when convenient
3	Significant damage	Repair work required	repair soon
4	Critical damage	Urgent repairs or strengthening work required	repair immediately
5	Ultimate damage	Bridge has failed	strengthening works or replacement required, road closure or TMP

Table 5.2 – Component Rating and Works Required Chart

The table on page 84 provides guidance on the rating for all elements. It provides indications of levels of defects within the Condition Rating classification (1-5). A structural component is a component which would cause the bridge to be structurally compromised or collapse if it failed. The type, variety and complexity of defects that can arise in bridges cannot be covered fully by examples etc, and therefore engineering knowledge, judgement and experience will be necessary. The overall condition rating of the bridge is generally based on the worst condition rating of any structural component in the bridge; i.e. if the bridge is in near perfect condition but one structural component is critically damaged the bridge will have an overall rating of 4 or 5. However, the Engineer, when compiling a bridge repair programme, may decide that a non-structural defective component is also a priority in terms of, for instance, public safety e.g. a missing parapet or safety barrier.

5.2.1 Engineering Inspection - Comment Boxes

There are two types of comment box available under Engineering Inspections, one general box and a component comment box. The general comment box provides the Engineer carrying out an Engineering Inspection with the opportunity to record an overall comment regarding the condition of the bridge and/or record details of the bridge not already covered by the Maintenance Inspection or the BIS. Such detail may include structural dimensions, extreme cover or near zero cover, plaque or pilaster information, angling access ways, or other relevant data, not previously recorded.

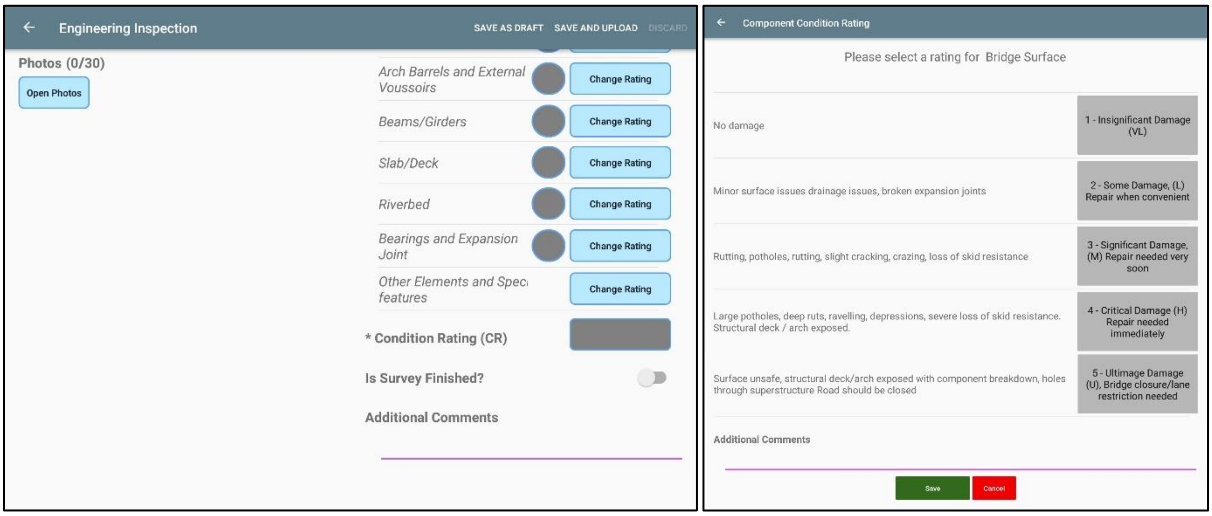


Figure 5.2 - Engineering Inspections – Comment Boxes

Engineers are also encouraged to insert comments on matters of conservation and unusual interest, or issues of concern, in order to better understand the structure and for the use of others at a later date. The Engineer may, however, choose to omit any or part of the information and simply add short text comments in the *component* comment box. Some examples of relevant information are provided below.

A. Describe the issue:

Brief Comment

- Three span stone arch bridge, with thin barrel thickness. Surface ponding.

Detailed Comment

- Triple span; approx. c8’ (2.4M) central arch plus 2 x approx. 6’(1.8m) segmental arches, (d=10”(0.25m)) in rough cut, rough coursed sandstone, in spate stream. Approx. 6’ high abutments, with dressed stone pilasters and coursed narrow limestone piers, single way traffic width, with grass margins, deck ponding evident. c0.6m crown fill. Date plaque ‘1794’ on upstream road side parapet face. Heavy rain, above average river flow.

B. Describe defects:

The Engineer can record details of the problems found at a particular structure. There are many possible defects and combinations of defects, which can arise in bridges and the Engineer must decide which would be relevant or of benefit to add here and are provided in addition to the component comment.

Brief Comment	▪ Cracks in central span, wet soffit.
Detailed Comment	▪ approx. 40mm wide diagonal crack from LHS to RHS, LHS cutwater running into central crown, second longitudinal crack approx. 2m from spandrel face, plus spandrel separation downstream side, all in same arch (arch No. 3). Substantial mortar loss in arch No. 2, upstream half with dripping evident, reflective of road surface ponding above.

C. Propose Remedial Action:

The Engineer can record proposals for the next step; e.g. possible site investigations, possible remedial works, scour inspections, material testing, structural assessments, etc.

- Trial holes at crown required, restrict loading.
- Breakdown of barrel integrity, high priority for repair. SI to establish 'D' and 'H' to assess load capacity, erect load restriction sign?

5.2.2 Engineering Inspection – Condition Rating of Components – Component Condition Rating (cCR)

This Engineer rates the condition of each component (cCR) - 14 in total. The Engineer shall enter a rating for each component, if present. The rating assigned to structural components dictates the overall condition rating of the bridge by, normally, assigning the highest rating of each of the structural components as the overall condition rating of the bridge. This rating can be overridden if the Engineer concludes that the cumulative effect of some structural component ratings would be greater than the highest rating of an individual structural component. Guidance is given in the table and condition guidance examples.

Example 1 - Barrel Cracks, cCR= 4, pier cCR =3: Overall structure CR =4.

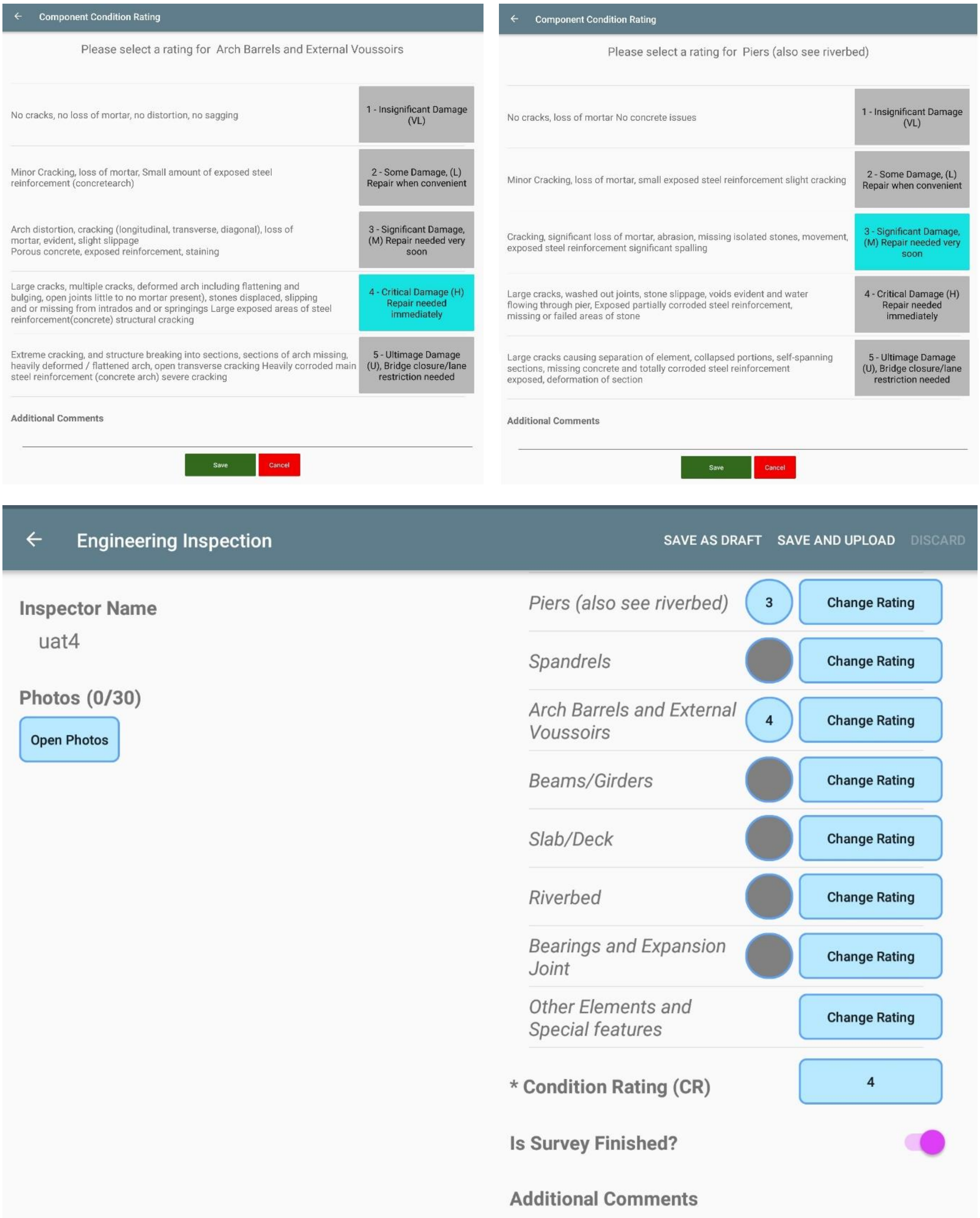
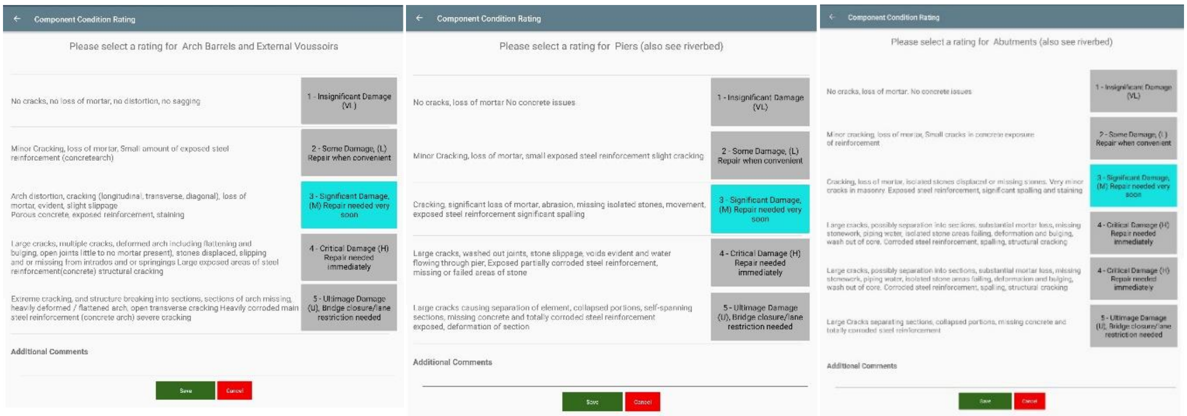


Figure 5.3 - Engineering Inspections – Example 1

Example 2 - Barrel Cracks, cCR= 3, pier cCR =3, Abutments cCR =3:Overall structure CR =4.



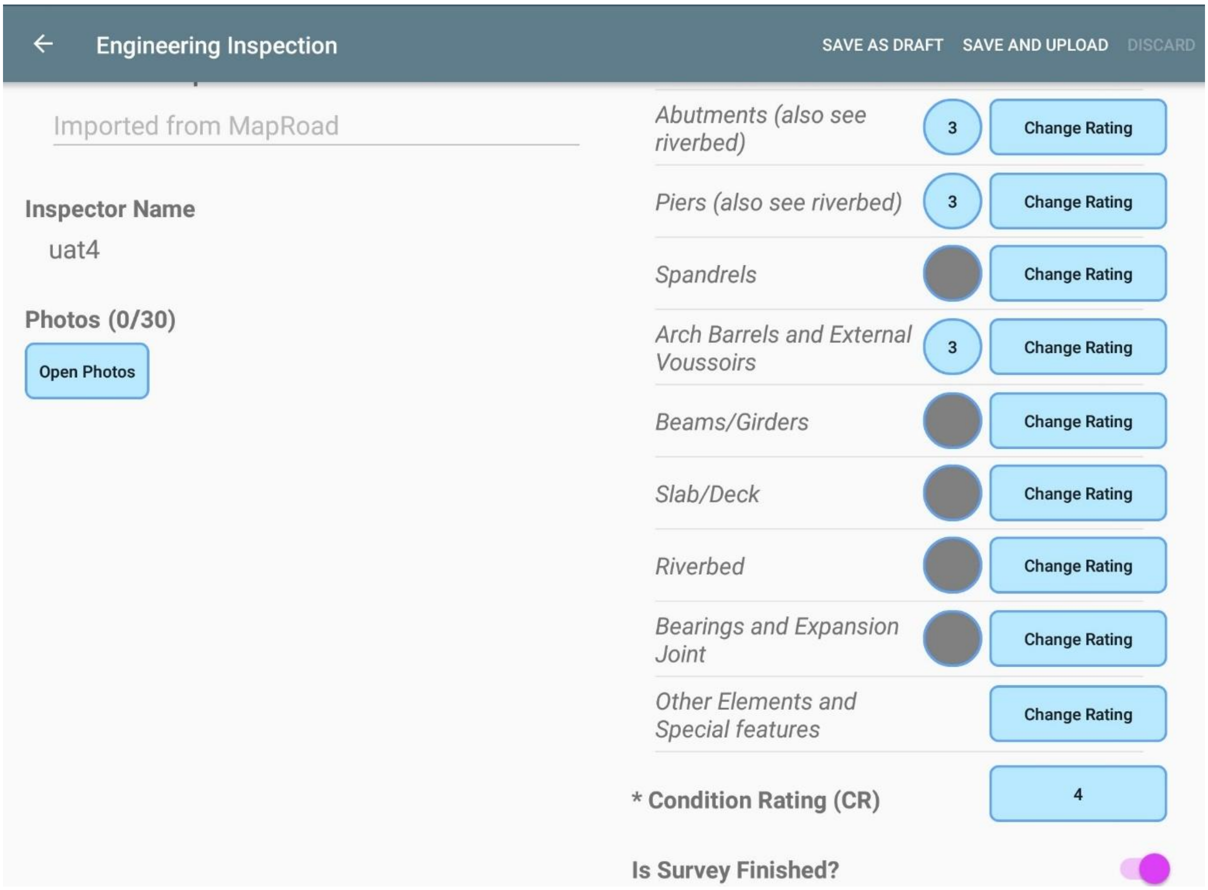


Figure 5.4 - Engineering Inspections – Example 2

5.2.3 Engineering Inspection – Overall Bridge Condition Rating (CR)

There may be situations where the Engineer considers that the overall CR is higher than any component rating (cCR), ie the accumulating effect. cCR =3 for piers, abutments and arch barrel may result in an overall Condition Rating (CR) rating of 4 for the structure.

5.2.4 Engineering Inspection – Photographs

Photographs form an essential part of the Engineering Inspection can be taken using the Application. Sufficient photographs (up to a maximum of 30) should be taken to show any/all defects found; e.g., Intrados cracks, barrel distortion, foundation issues, scour holes, exposed rebar, sagging, bulging, corrosion, etc. This may or may not require a flash light- trial and error may be necessary. Inaccessible central span defects may often be photographed using a zoom facility from a distance. Photographs of other salient matters, including vegetation and tree growth, blockages, impact damage, hump backs, unusual features, services, etc, should also be taken, if not already captured when carrying out the Bridge Inventory Survey (BIS).

5.5 The Ratings Assistance Table

The table on the following pages provides assistance to Local Authority Engineers tasked with assigning condition ratings to bridge components, however, it is not intended as a substitute for technical education, training or experience

*This means the component is a **STRUCTURAL** component.*

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Bridge Surface	No damage.	Minor surface issues, drainage issues, broken expansion joints.	Rutting, potholes, slight cracking, crazing, loss of skid resistance.	Large potholes, deep ruts, ravelling, depressions, severe loss of skid resistance. Structural deck/arch exposed.	Surface unsafe, structural deck/arch exposed with component breakdown, holes through superstructure. Road should be closed.
Footpath Verges rubbing strips Medians	No damage.	Small potholes, ruts, hairline cracks, porous verges, vegetation growth.	Potholes, cracking of surfacing, shrub growth, services exposed.	Large potholes, major depressions, paving bricks displaced or lifting and broken paving slabs, shrub and tree growth lifting elements.	Large pothole, hole through superstructure, footpath should be closed.
Parapets and Safety Rails	Minor loss of mortar in masonry. Some painting of railing required.	Minor stone issues, loss of mortar. Light vegetation growth. Painting of metal railing required.	Loose stones, loose mortar, slight leaning, tilting, bulging or impact damage. Bolts corroded, isolated vertical rail missing, safety barriers slightly damaged, visibility reduced due the vegetation growth.	Parts of masonry parapet missing, part of parapet collapsing. Heavy vegetation or shrub/tree growth - roots displacing walls. Missing railing, badly damaged safety rails, substantially reduced iron or steel cross-section through rusting.	Missing railing or parapet, danger of accident.

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Embankment and Revetments	Minor stone loss, light vegetation.	Some stone loss, vegetation growth at joints, significant mortar loss. Slight scour to base or at drainage outlets.	Embankment material starting to break down, isolated base displacements, shrubs growing, Scour evident. Minor flanking erosion. Masonry walling isolated stone loss.	Localised failure of slope and construction, masonry collapsing, Tree growth deforming structure, Major erosion at base or flanking. clear settlement/movement self-arching and breaches, rock armour moving away from base, base rotation, severe scour Road pavement failing.	Undermining of approach road, partial collapse of structure, road pavement collapsing.
Wingwalls and Retaining walls	Very minor bulging, leaning, cracking.	Minor: bulging, cracking, mortar loss, vegetation. Slight spalling of concrete. Slight rotting in crib walls.	Cracking, bulging, leaning, tilting, mortar loss, some stone loss. Shrubs and roots slightly moving stones. Spalling of concrete, exposure of reinforcement. Isolated timber member's failure, infill escaping.	Significant: leaning, bulging, cracking, impact damage (some parts broken off), sliding, heaving, undermining. Isolated stone work areas collapsing or falling off bulges and leaning walls. Isolated areas of crib walling, reinforced earth failing.	Extreme bulging, leaning, tilting, cracking, sliding. Partial collapse of any type of wall.

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Abutments (also see riverbed)	No cracks, loss of mortar. No concrete issues.	Minor cracking, loss of mortar, Small cracks in concrete, exposure of reinforcement.	Cracking, loss of mortar, isolated stones, displaced or missing stones. Very minor cracks in masonry. Exposed steel reinforcement, significant spalling and staining.	Large cracks, possibly separated into sections, substantial mortar loss, missing stonework, piping water, isolated stone areas failing, deformation and bulging, wash out of core. Corroded steel reinforcement, spalling, structural cracking.	Large Cracks separating sections, collapsed portions, missing concrete and totally corroded steel reinforcement.
Piers (also see riverbed)	No cracks, loss of mortar. No concrete issues.	Minor Cracking, loss of mortar, small exposed steel reinforcement slight cracking.	Cracking, significant loss of mortar, abrasion, missing isolated stones, movement, exposed steel reinforcement, significant spalling.	Large cracks, washed out joints, stone slippage, voids evident and water flowing through pier. Exposed partially corroded steel reinforcement, missing or failed areas of stone.	Large cracks causing separation of element, collapsed portions, self-spanning sections, missing concrete and totally corroded steel reinforcement exposed, deformation of section.
Spandrels	No cracks bulges, mortar loss.	Minor cracking, tilting, bulging, water egress, minor vegetation.	Cracking, bulging, leaning, sliding, mortar loss, substantial vegetation/shrub growth.	Extensive cracking, stone loss, rotation, substantial bulging, tilting, leaning with stones falling, sliding. Shrub and tree growth moving masonry.	Portions collapsing, extreme leaning bulging, compression failure, separation and articulation.

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Arch Barrels and External Voussoirs	No cracks, no loss of mortar, no distortion, no sagging.	Minor Cracking, loss of mortar. Small amount of exposed steel reinforcement (concrete arch).	Arch distortion, cracking (longitudinal, transverse, diagonal), loss of mortar, evident, slight slippage. Porous concrete, exposed reinforcement, staining.	Large cracks, multiple cracks, deformed arch including flattening and bulging, open joints little to no mortar present), stones displaced, slipping and or missing from intrados and or springings Large exposed areas of steel reinforcement(concrete) structural cracking.	Extreme cracking, and structure breaking into sections, sections of arch missing, heavily deformed/flattened arch, open transverse cracking. Heavily corroded main steel reinforcement (concrete arch) severe cracking.
Beams/ Girders	Very minor cracks in concrete. Paint rusting on steel girders and beams.	Minor cracks in concrete soffit and beam webs or reinforcement visible, metal beams showing rust and paint heavily flaking.	Cracks in concrete, minor concrete spalling, staining, some rebar exposed. Leaching. Extensive areas of beams without paint (protective coating), rusting steel work.	Concrete heavily spalling, structural main reinforcement rusting, evidence of structural distress at supports or midspan. Structural steel members losing cross-section due to extent of rust, distortion of members, rivets or welds breaking down.	Deflection of beams discernible, steel reinforcement heavily rusted and reduced in cross-section. Substantial structural cracking. Steel beams extensive corrosion and reducing load carrying capacity. Flanges and webs only partially existing.

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Slab/Deck	None or very minor cracks, no spalling in concrete. No rust.	Minor crack and slight evidence of concrete surface breakdown or carbonisation of concrete soffit walls. Paint missing on steel trough units Minor light rusting of steel or iron.	Cracks in concrete, porous concrete, minor concrete spalling some rebar exposed. Extensive areas of soffit without paint (protective coating), rusting steel work	Concrete heavily spalling, structural main reinforcement rusting, evidence of structural distress, Structural steel work corroding through significant thickness of member, rivets or welds breaking down Composite decks: materials separating, some components in-effective.	Deflection of slab discernible, fracture in concrete, sagging, steel reinforcement heavily rusted and reduced in cross-section, substantial areas of spalling. Steel soffits suffering from extensive corrosion and reducing load carrying capacity. Failure of some components in composite decks.
Riverbed	No Erosion or scour evident.	Minor bed or bank erosion, minor scour evident. River bed below structure base. Bed protection showing minor issues.	Evidence of minor undermining of abutments, piers, cutwaters or training Bed protection showing isolated areas of failure: pitching stones missing, concrete portions missing.	Serious erosion and scour. Bed protection failed over a substantial area. Abutments, piers, cutwater etc. undermined and scour holes at piers visible, foundations exposed Masonry blocks missing and water seeping through the structure between spans.	Major erosion & scour. Substantial bed erosion, foundations exposed or partially missing. Piers deforming, tilting, suspended, partially missing Abutments only partially founded, structure redistributing load, cantilevering, failure imminent.

COMPONENT	RATING (cCR)				
	1	2	3	4	5
	Coarse Damage and Repair equivalence				
	Insignificant Damage (VL)	Some Damage (L) *Repair when convenient*	Significant Damage (M) *Repair needed very soon*	Critical Damage (H) *Repair needed immediately. Consider Load restriction/propping*	Ultimate Damage (U) *Bridge closure/lane restriction needed*
Bearings and Expansion Joint	No damage or insignificant. Clear any blocked associated drainage systems, if necessary.	Minor cracks in rubber. Steel components starting to rust. Water ponding evident on bearing shelf-etc. Surface cracks in joint in road.	Loose, cracked rubber pads. Steel components rusting. Surfacing starting to break up at expansion joints.	Rubber bearing pads delaminating or starting to break down. Steel bearings heavily rusted into steel components and bearing plinths. Damaged expansion joint, twisting, lifting, jammed, carriageway has large pot holes at joint, foot path broken up.	Bearing components excessively reduced in cross-section due to rust, bending, buckling of elements, nuts shearing. Road surface depressed or disintegrating: unsafe. Road should be closed
Other Elements and Special features. Other elements may occasionally be present-the user can input descriptions of the component and its condition in the appropriate column. E.g. channel blockages.					
OVERALL BRIDGE CONDITION RATING (CR)	**1**	**2**	**3**	**4**	**5**

Table 5.3 – The Ratings Assistance Table

6

NON-SITE BRIDGE DATA

6 NON-SITE BRIDGE DATA

6.1 Introduction

Having completed a BIS, MI or EI a bridge (or culvert) on site there is further work to be done back at the office on MapRoad PMS. As with all civil engineering works (whether maintenance or project-like in nature) certain key background information or 'non-site' bridge data supports the accurate production of contract documents and augments bridge records generally. The 'non-site' data includes a number of dialog boxes prompting the user to check the categories. A bridge name is the most obvious and should be inserted.

6.2 Bridge Name

Data that relates to practical administration:

To begin with, the bridge name needs to be established. Use the bridge name on the Ordnance survey map where it exists or else the name in local use. Where a name does not exist one must be created, possibly from the townland(s) address. On the Ordnance Survey Discovery Mapping above Drumlahan and Mount Town bridges are named but the bridge between them on the same river is not.

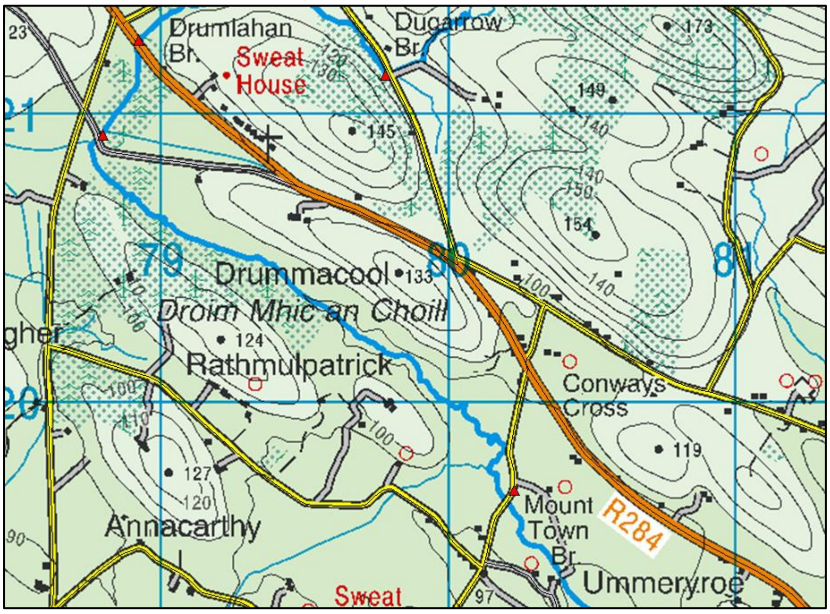


Figure 6.1 – Ordnance Survey Mapping – Named Bridges Included

6.3 Additional Useful Data

Data concerning location descriptors and catchment characteristics:

Bridges form a key integral segment of our Nation's physical infrastructure. In an overall way, National and Local Government Agencies manage several elements of this infrastructure and, therefore, it is to be expected that multi-departmental functional responsibilities sometimes overlap and over-arch depending on the 'bridge' location. Typical data includes a bridge' 'Protected' status (listed in Record of Protected Structure in County/City Development Plan) and National Inventory of Architectural Heritage (NIAH) status (available at http://www.buildingsofireland.ie). Various consents, including Ministerial Consent, may increase lead-in time for planned works.

Ecological and environmental constraints usually relate to the ecological status of the watercourse and surrounding area e.g. candidate Special Areas of Conservation [cSAC's], Natural Heritage Areas [NHA's], Special Protection Areas [SPA's], Natura 2000 sites, [see www.npws.ie/protected-sites]. Bridge repairs works in these areas may be restricted to certain times of the year relating to the habitat in question. Similarly, Inland Fisheries may wish to restrict 'in stream works', to avoid interference with fish movements at certain times of the year. Other species of concern include: Lamphrey and Fresh Water Mussels. Forward planning and consultation is advised. N.B. masonry bridges themselves, are sometimes temporary homes for bats and nesting birds and NPWS may restrict works to outside the breeding season. Often, nesting facilities can be incorporated into the repair works to mutual benefit. Additionally, useful attributes include Municipal and Area Engineering areas, River Basin Districts and Geological data.

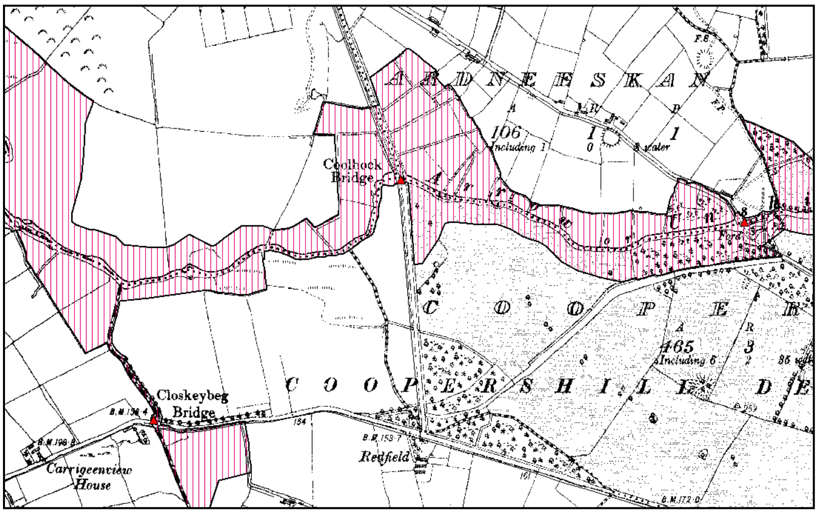


Figure 6.2 – Ordnance Survey Map Extract – cSAC areas overlaid (hatched area)

6.4 Data Affecting the Design of Repairs

Data that could affect the design of repairs:

The age of a bridge is sometimes recorded on stone plaques that form part of the bridge, and some pre-1837 bridges appear on the first edition O.S. maps. Many factors also influence the design of repairs. Why has the problem arisen? Has the usage increased or type of vehicle crossing the bridge changed? Is there Annual Average Daily Traffic (AADT) data available - this may have been measured or estimated. Do collision statistics exist? Is the road over the bridge part of a haul route? Is there a record of earlier repairs and surveys? Is consultation with the OPW required regarding the Arterial Drainage Act, particularly regarding new / replacement structures. (re: Section 50)? The image below is a 1st Edition Ordnance Survey map extract showing three named bridges in existence in 1837. Both Drumlahan Bridge and Dugarrow Bridge still support public roads

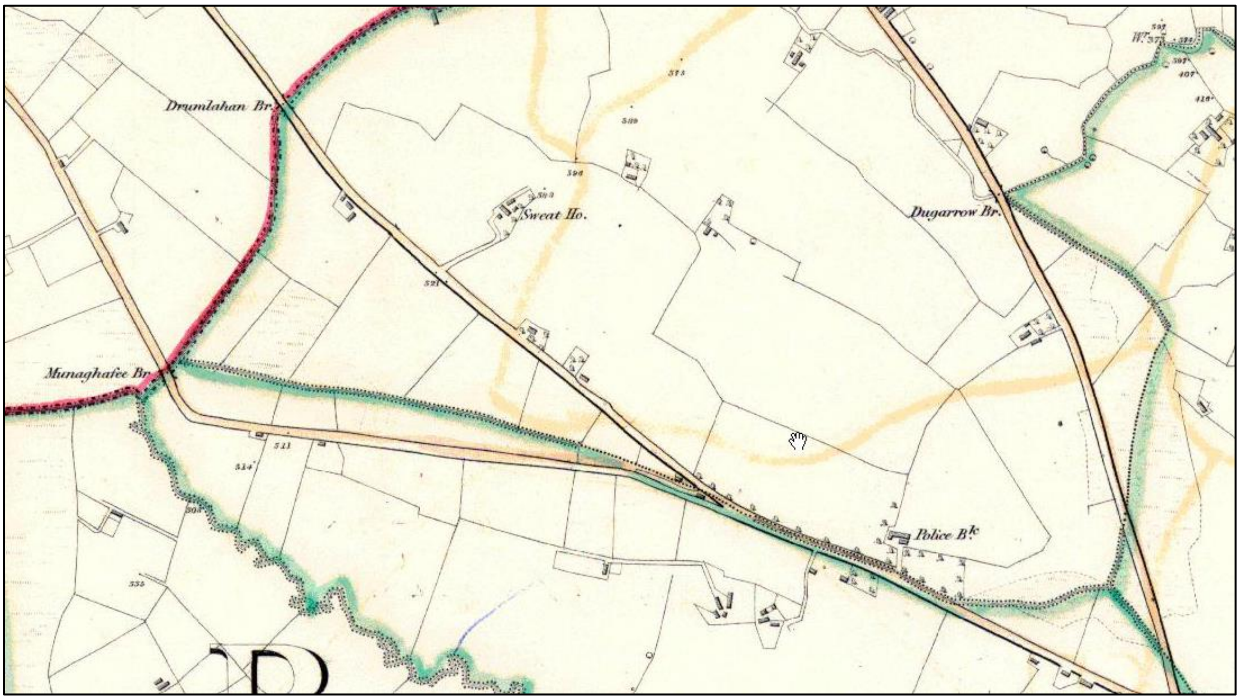


Figure 6.3 – Ordnance Survey Map Showing 1837 Bridges

6.5 Other Data

Historical data from local history books and journals as well as folklore can sometimes have a direct bearing on best repair/replacement options. For example, many bridges were intentionally damaged during the Civil War and War of Independence and it is important that the engineer factors this into ‘reading the structure’ and assessment of the best repair option.

Therefore, all information that supports the efficient planning and execution of such works should be recorded in a suitably organised and consistent manner. Experience and local knowledge will quickly establish the priority and relevancy of the many items that form part of ‘non-site’ bridge data.

7

CONSERVATION PRINCIPLES

7 CONSERVATION PRINCIPLES

7.1 Introduction

Masonry arch bridges, particularly those made of stone, make up the bulk of the nation's road bridge stock. They have an aesthetic appeal and, to varying degrees, have historical significance locally, regionally or, occasionally, nationally. Some bridges may also have engineering, scientific or architectural significance. They contribute to '*a sense of place*', and the public increasingly value heritage and culture and have an expectation for retention and appropriate repair. Virtually all masonry arch road bridges are at least 140 years old. Many are nearer 200 years old and a substantial number predate 1800 AD and even 1700 AD. At least one 800-year-old public road bridge currently carries vehicular traffic. These bridges have served us well for centuries, often despite a lack of much or any maintenance and modern vehicular loadings unimagined by those that built them. Additionally, early iron, steel and concrete bridges may have industrial heritage significance and form part of Ireland's engineering history, be it local, regional or national. They too shall be considered in a conservation context.

Figure 7. 1 – Example of early rural in-situ concrete bridge with decorative parapet feature at abutments

The conservation approach and principles shall be the default position when considering all masonry arch road bridges (whether listed or not). The Department of Transport, Tourism and Sport endorses the conservation approach for all masonry arch bridge works. AM-STR-06051 (BD89/15) – '*The Conservation of Road Structures*' acknowledges the infrastructural and heritage value of these bridges, regardless of protected status.

Masonry arch bridges shall not be replaced without very good reason. An appropriately experienced Chartered Engineer, aware of conservation aspects of Local Authority responsibilities, preferably with structural experience in masonry arches and fully aware of this document, should inspect the bridge. Only after this engineer is prepared to recommend that replacement is really necessary, should such action be allowed. Recent tests and structural assessments have shown many masonry arch bridges are currently outlasting concrete extensions built on to them in the last 80 years, the concrete portions are now being replaced due to inadequacies, whilst the masonry portion lives on.

Conservation principles include;

- allowing a structure to behave structurally as intended and originally built,
- understanding the issues, i.e. being able to 'diagnose the cause', not merely addressing the 'symptoms' of a detect,
- repairing 'like with like', (including workmanship and materials),
- minimal effect on appearance and fabric, including minimal introduction of new materials,
- minimal intervention,
- maximising reversibility,
- respect for the structure and setting,

Refer to: AM-STR-06051 (BD89/15) *and BS7931/98, Built Heritage Publications i.e. Dept. of Culture, Heritage and the Gaeltacht for more details.*

Ordinary Portland Cement (OPC) was not used in masonry arch bridge construction (with a few late nineteenth century exceptions) and should not be used in the repair of stone arch bridges, be it, re-construction, repairs or pointing. Therefore, a stone bridge, that **DOES NOT** have protected status, should be repaired similarly to those with protected status. Engineers have a responsibility, as custodians of these old structures, to maintain them for future generations to enjoy. Returning the bridge to its original condition should be the first objective, repair should be a secondary consideration and reconstruction and intervention (Conservation definition), the third consideration. Restoring a 200-year-old bridge, that has been subjected to vehicular loading, to a good condition, may be sufficient to last another century. Strengthening would be the next consideration, if justified.

Using conservation principles and traditional materials **DOES NOT** necessarily cost more than inappropriate repairs or replacement, is better for the bridge, heritage, society, future generations and our carbon footprint. It only requires a bit more effort and understanding. Therefore, with direct labour works, or in procuring Contractors (or Consultants) to be engaged in masonry bridge works, the LA shall ensure that the above approach is taken.

7.2 Lime Mortar and Basic Masonry

Lime has been used as a building material for thousands of years. Arch bridges and aqueducts built by the Romans and are still standing today, used lime mortars. Most of our stone arch road bridges were built with lime mortars also, the oldest are about 800 years old and the youngest ones were built around 1880.

The use of Ordinary Portland Cement (OPC), started in the mid 1800's and gained wider use in the latter quarter of that century when masonry arch road bridge construction was in decline in favour of both concrete and metal structures. OPC mortar and concrete had advantages of high compressive strength, quick set, early strength gain and high density. The properties of lime mortar has its advantages when working with and repairing authentic arch bridges built of stone.

Lime mortar is weaker and more porous than stone and the lime mortar joints allow some movement/deformation between the stone units and in the structure and provide conduits that allow water/moisture and salts trapped in the structure to escape by capillary action to the atmosphere through the lime mortar joints, without damaging the stones (or bricks).

Lime mortars consist of a mixture of binders - the lime, usually white or off white in colour, aggregates, water and sometimes additives, in the proportions required to achieve proper workability in the fresh state and adequate physical, mechanical, aesthetical and durability properties in the hardened state. It is easy to build and point with as it sticks to the trowel or jointing tools, better than OPC.

In addition to having a low carbon impact, lime products have the following benefits;

- Repairing 'like with like' is an essential principle when working on /repairing old structures.
- Self-Healing. Masonry bridges built with lime are subject to small movements mainly due to live loading and sometimes fine minor thermal cracking. Water penetration can dissolve the 'free' lime and transport it. As the water evaporates this lime is deposited and begins to heal the cracks. This process is called autogenous, or self-healing.
- Breathability – lime bedding and pointing allow spandrels and abutments to breathe and prevent damage caused by trapped moisture.
- Sacrificial material. Lime mortar is softer than the masonry building blocks, meaning that the lime will deteriorate and take structural strain, it may wash out of the joints over the centuries, if not maintained, but it prolongs the life of the structural masonry units and re-pointing is relatively inexpensive and easy to carry out.
- Durability – if applied correctly, lime construction can last 200 years without needing to be replaced and re-pointing will extend longevity
- Limes, both hydraulic and non-hydraulic, have a more pleasing appearance, due to the double reflective index of the lime. If lime pointing is finished correctly, i.e.' flush' and with a beaten finish, [exposing the aggregate], then the results conform to traditional and conservation principles and is in character with our old bridges.

7.2.1 What is Lime?

From a practical viewpoint lime is substituted for OPC, in mortar for masonry building and pointing etc. Both Natural Hydraulic Lime (NHL) and Non-Hydraulic are supplied /available in 25kg bags. 'Lime' is made through heating Limestone (Calcium Carbonate) at high temperatures in a kiln. The Lime (Calcium Oxide) produced can then be rehydrated to form Hydrated Lime (a powdery substance), or 'slaked' and matured for 2 -3 months in an excess of water to create Lime Putty (which has a similar texture to toothpaste) – both of these products form the basis of lime mortars, plasters and washes. Depending on the purity of the Limestone used, types of lime can be produced with varying properties and strengths.

Limestone produces Non-Hydraulic Lime, (hot lime), which relies on air (carbonisation) to set and will not harden in permanently damp conditions and is vulnerable to frost before carbonisation. However, limestone with clay particles, containing silicates or alumina, produces Naturally Hydraulic Lime (NHL), which can set in the presence of water or under water, with little to no reliance on air (carbonisation). This makes NHL particularly suitable for masonry bridge building, repairs and pointing.

It is considered that most limes used in old arch river bridge construction were hydraulic to some degree, as they have been subject to submersion, flooding and/or continuous wetting and drying from all directions, yet the structures are still standing after centuries. NHL is classified into three different strengths: 2, 3.5 and 5 (based on compressive strength, in newtons per square millimetre).

Since around 2014 there has been a resurgence in the interest and use of hot-lime i.e. non-hydraulic lime, for building restoration, however its use in masonry river bridge repairs and pointing work is not generally recommended, due to the aggressive and wet environment at river bridges and the live loading they must endure.

7.2.2 Lime Pointing and Finishing - Examples

Left: Appropriate pointing to rough coursed red sandstone, flush pointing and exposed

Figure 7.2 – Appropriate Lime Pointing

Figure 7.3 – Appropriate Lime Pointing

Above: Appropriate flush NHL5 pointing with exposed aggregate finish to coursed, rough dressed limestone bridge spandrel.

Inappropriate pointing.

OPC 'strap' pointing to rough cut, rough coursed limestone parapet. There is no tradition of 'Strap' pointing in Ireland, and OPC pointing is too hard and dense and prohibits the movement and evaporation of moisture from within the structure, with detrimental effect on the stonework (often unseen).

Figure 7.4 – Inappropriate opc 'strap' Pointing

Masonry – examples of good and poor practise in bridge works.

Example of well-balanced rough cut, horizontally bedded parapet wall (masonry) and continued throughout in this major conservation repair project.

Figure 7.5 – Good Masonry Parapet Wall

Example of inappropriate masonry repair work. Unbroken vertical joints, stones higher than length, joints too wide in places.

Figure 7.6 – Inappropriate Masonry Repair Example

Figure 7.7 – Acceptable Random-rubble Repair Work

Example of acceptable random rubble repair work. The emphasis is to repair 'like with like'. It is difficult to define just where the original masonry ends and the new repair/rebuild starts and therefore the result is successful.

Example of poor-quality random rubble masonry repair work. Lack of horizontal emphasis, (i.e. sloping beds), inappropriate triangular and irregular stones, angled 'snecks', poor balance, some very wide joints and unfinished mortar at lower level.

Figure 7.8 – Poor Quality Random-rubble Repair Work

Figure 7.9 – Acceptable cut stone repair

Example of acceptable cut horizontally coursed repair/reconstruction. The work shows horizontal emphasis and bedding, broken joints and well-balanced sandstone masonry work.

Early Steel and Concrete Bridges.

Early steel beam bridges are moderately common in rural Ireland, some with 'jack arch' type deck infill and some with superficial concrete cover to the main steel beams. Some of these may be close to a century old and worthy of retention, but assessment may warrant restricted axle loads. Some early reinforced concrete bridges may also have technical, aesthetic or historic merit and may be fine examples of early bridge engineering in new materials of their day.

Iron Road Bridges.

As far as we are aware there are very few cast or wrought iron bridges supporting public roads in the State. However, some do exist and should be given appropriate consideration and conservation principles shall apply (they may well be 'listed'). Assessing these bridges may require specialist advice and analysis. Below is an example of an unusual braced lattice girder road bridge spanning the River Moy. Built in 1881, the wrought iron superstructure was renovated in 2004.

Figure 7.10 – Wrought Iron Bridge

7.3 Arch Bridge Repair Strategy

Masonry arch bridges, particularly those of stone, make up the bulk of the Nation's road bridge stock, estimated at above 80% of the total, non-national road, bridge stock. They have an aesthetic appeal and to varying degrees have historical significance locally, regionally or occasionally nationally. They have survived at least a century and possibly several, despite modern vehicular loading and perhaps lack of maintenance.

Since around the turn of the century (2000 AD) it has been realised that these structures are often more robust than previously thought and that repairing these bridges using traditional materials and methods is often better and cheaper than other options.

NB1: The use of Portland cements should, in general, **be avoided**, in favour of lime mortars (NHL). Replacement is rarely necessary and usually more expensive than conservation repairs.

NB2: It is culturally, aesthetically and socially more acceptable to follow conservation principles and retain these functioning engineering heritage assets (regardless of the 'protected status' of the old structure).

Seminars involving talks on bridge conservation principles are now becoming more common and specific Local Authority bridge training is being planned. These principles should be the core of repair strategy and not an afterthought. Local Authority Engineers are encouraged to be leaders and to take responsibility for what is their engineering heritage and not rely on other disciplines regarding conservation of bridges. These bridges may last another two hundred years for future generations to enjoy if appropriately repaired.

LOCAL AUTHORITY ENGINEERS (AND THEIR CONSULTANTS IF USED) SHOULD WORK TO PROTECT OUR ENGINEERING-BUILT HERITAGE, REGARDLESS OF THE 'PROTECTED STATUS' OF THE OLD STRUCTURE. LA'S SHOULD BE CUSTODIANS AS WELL AS OWNERS

APPENDIX A

ENGINEERING INSPECTION RATING GUIDE

A APPENDIX A – EI RATING GUIDE

This appendix provides assistance to Local Authority Engineers tasked with assigning condition ratings to bridge components, however, it is not intended as a substitute for technical education, training or experience

A. Engineering Inspections

COMPONENTS, AND THE BRIDGE OVERALL, ARE GIVEN A RATING BASED ON THE CONDITIONS BELOW		
RATING	***LEVEL OF DAMAGE***	***INTERVENTION***
1	Insignificant damage	minimal work required non-critical.
2	Some damage	minor maintenance work required, repair when convenient.
3	Significant damage	maintenance work required, repair soon.
4	Critical damage	urgent repairs or strengthening work required, repair immediately.
5	Ultimate damage	bridge has failed, strengthening works or replacement required, road closure or management plan required.

Those carrying out Engineering Inspections are required to give an opinion on the condition of the structure. The examples in this Appendix and Chapter 5 provide guidance on the ratings and the prioritisation of repairs.

The overall condition rating of the bridge is generally based on the worst condition of any structural element in the bridge. A structural element is a component which would cause the bridge to collapse if it failed, i.e. if the bridge is in near perfect condition but one structural component is critically damaged, the bridge will have an overall rating of 4 to 5 as it is structurally compromised and near collapse.

A.1 Condition Rating Guide

This section provides photographic examples and suggested ratings to be assigned to individual bridge components. cCR throughout these examples means the Component Condition Rating and CR means Condition Rating, this CR is the overall Condition Rating assigned to the bridge.

A.1.1 Bridge Surface

Figure A.1 – Hole in Carriageway to River Bed Below

Figure A.2 – Surface Water Ponding (and permeable grass verges)

A.1.2 Footpaths, Verges, Rubbing Strips and Medians

Figure A.3 – Grass Verges and Hedge Growth in Verge and Parapet

A.1.3 Parapets and Safety Rails

Figure A.4 – Concrete Parapet Partially Missing

Figure A.5 – Impact Damage to Masonry Parapet

Figure A.6 – Broken Railing on Triple Span Bridge

Figure A.7 – Missing Parapets and Spandrels

A.1.4 Embankments and Revetments

Figure A.8 – Bridge with Sloping Retaining Wall

Substantial bridge structure with sloping retaining wall contiguous with bridge, repaired within the last 15 years. NB: height of parapet above road surface is less than 500mm and is therefore sub-standard. This may warrant a high condition rating (e.g. cCr=4).

Figure A.9 – Revetment Supporting Road in Tidal Zone (masonry bridge out of view)

A.1.5 Wingwalls and Retaining Walls

Figure A.10 – Masonry Wingwalls and Retaining Walls

Figure A.11 – Collapsing Outer Stone on Wingwall

Figure A.12 – Missing Stone at Water Level

Figure A.13 – River training wall upstream and contiguous with abutment

Excessively leaning wingwall, retaining c 2.8m of fill and busy local primary road forming part of a protected structure

Figure A.14 – Leaning Wingwall

A.1.6 Abutments

Figure A.15 – Abutment Failure

Serious abutment failure, due primarily to scour; little to no support of road above

A.1.7 Piers

Figure A.16 – Cement Render Failing Exposing Weak Mass Concrete to Greater Weathering

Figure A.17 – Collapsing, buckling pier and stone lintels failing and falling

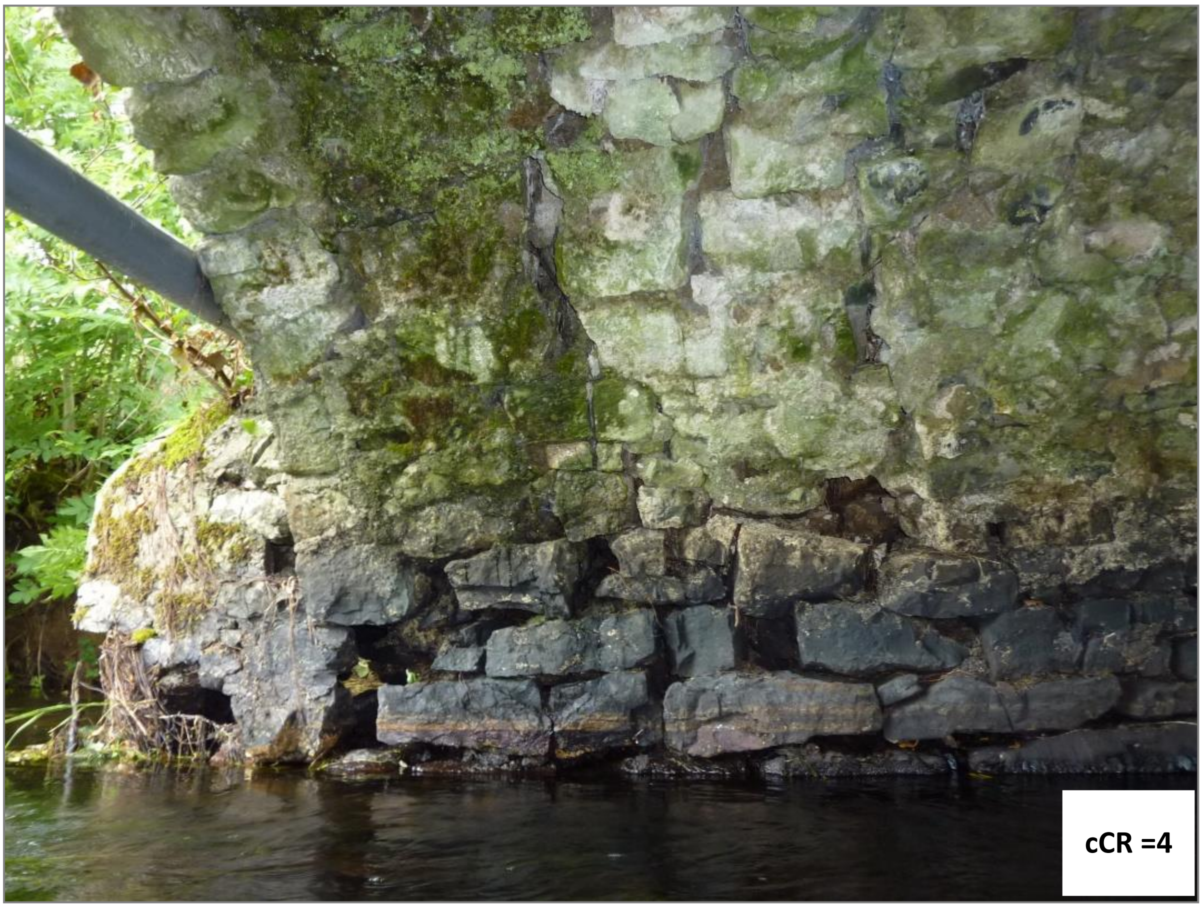


Figure A.18 – Washout and Pier Failure (arch breaking into discrete sections)

Figure A.19 – Scour at Pier Head and Pier Causing Collapse of Cutwater, Part of Pier and Arch

Road closure required for extended period.

A.1.8 Spandrels

Figure A.20 – Tree Roots Boring into Barrel

Tree growth has knocked off spandrel and parapet and roots are boring into barrel. Needs to be removed. Extreme winds might over turn the tree and with it, pull down part of the bridge.

Figure A.21 – Leaning and Bulging Spandrel Wall

A.1.9 Arch Barrels and External Voussoirs

Figure A.22 – Transverse Cracks in External Voussoirs

Distorted arch showing transverse cracks in external voussoirs, evident across barrel and in spandrel.

Figure A.23 – Missing Mortar, Sagging and Stone Slippage

Bridge arch with various longitudinal cracks, separating the arch into individual sections

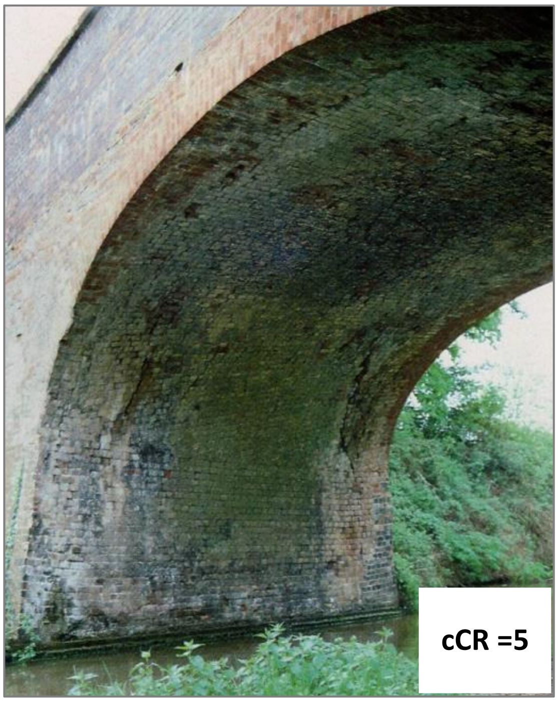


Figure A.24 – Cracked Arch

Rough coursed random rubble stone arch with longitudinal cracks separating the arch into

Figure A.25 – Cracked Arch

Figure A.26 – External Ring Isolation from Arch Barrel

A.1.10 Beams/Girders

Figure A.27 – Cracks in Soffit

Common concrete beam deck with slab. Unknown reinforcement: without removal of concrete and exposure of steel it is difficult to estimate condition and load carrying capacity of deck and beams until steel configuration established. Cracks in the cementitious soffit may help in consideration of overloading. Further Investigations required to determine cCR.

Figure A.28 – Water Seepage

Steel beams supporting RC deck slab. Water seepage evident from road surface

Figure A.29 – Main Reinforcement Rusting in Main Beam

Figure A.30 – Exposed Steel Flange

Typical beam/slab (trough deck) configuration, not uncommon in rural Ireland. This elevation photo shows an exposed steel flange component. Further exposure would be necessary to ascertain if the steel formed part of an encased universal beam (UB) or rolled steel joist (RSJ), or more likely was of some 'other' section. cCR=3, but further investigation required asap.

A.1.11 Slab/Deck

Typical rural concrete slab bridge deck. Compromised and unknown structural deck in poor condition. Assessment of strength of deck required. asap. Often construction drawings or other records do not exist. Load restriction to be considered?

Figure A.31 – Compromised Concrete Slab Deck

Composite Decks

Figure A.32 – Compromised Flanges

Composite deck. Possibly universal beams(UB) or RSJ. Lower flange clearly compromised in critical locations. Further investigations required asap. Possibly a load restriction warranted.

A.1.12 Riverbed

This section should be considered in conjunction with abutments and piers above.

Figure A.33 – Riverbed cCR=1

High quality, intact, masonry bed pitching preventing scour

Most of the cut masonry stone bed pitching is missing, resulting in undermining of the abutments.

Figure A.34 – Riverbed cCR=4

Structure located over mountain stream cCR=4
Previous in-situ concrete bed protection failed.
Steep mountain runoff on Spate river. Pier stability threatened cCR=4

Figure A.35 – Bed Protection Failure

Concrete pier in relatively good condition but threatened by localised scour. Upland catchment concrete bridge on spate river, bed scour threatening stability of pier and abutments.

Figure A.36 – Localised Scour

A.1.13 Bearings and Expansion Joints

Figure A.37 – No Bearing Pads or Strips Evident.

Presumed concrete on concrete supports, no signs of bearing or crushing failure.

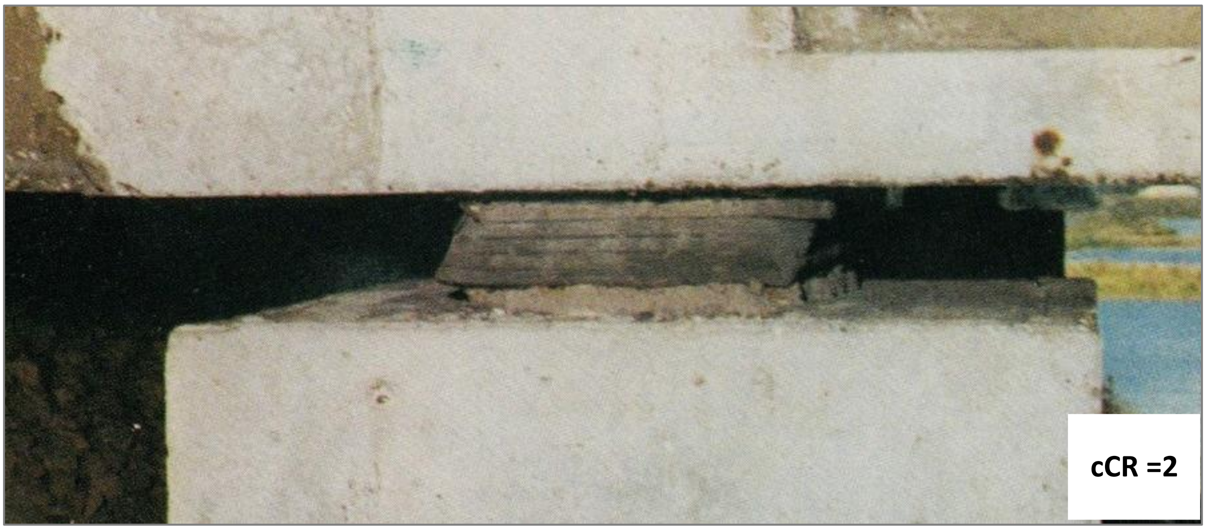


Figure A.38 – Horizontal Shear Failure of Elastomeric Bearing.

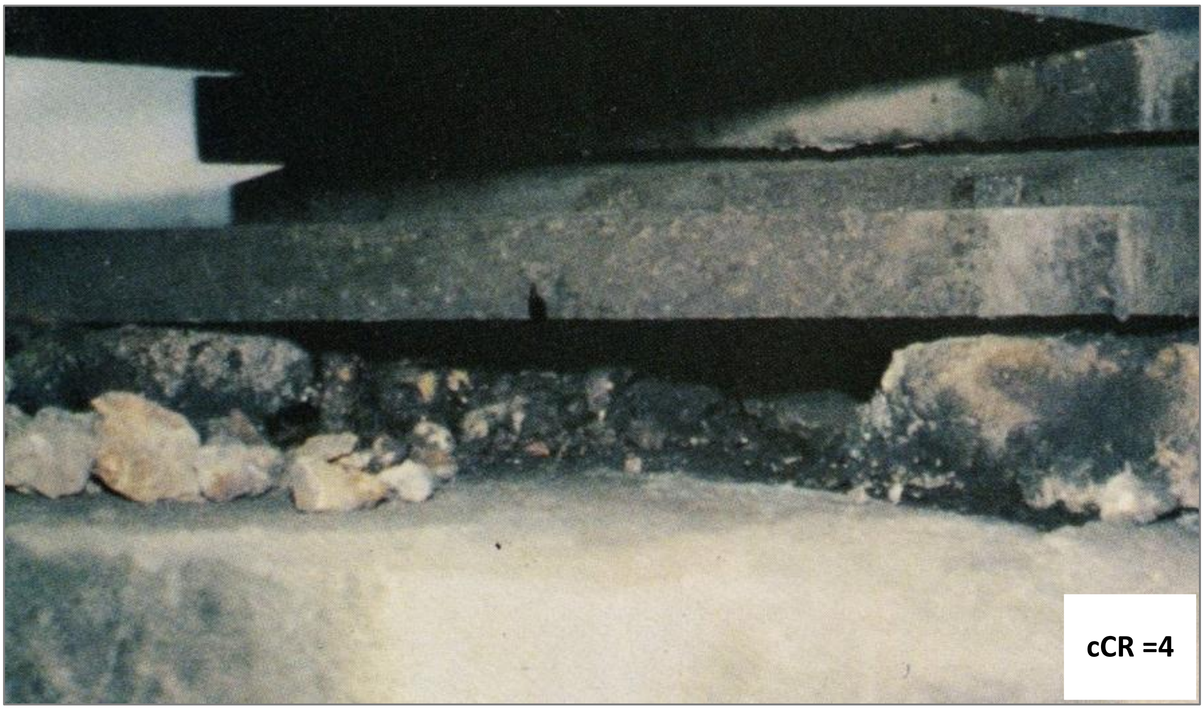


Figure A.39 – Bearing Seat Failure.

Figure A.40 – Breakdown in Buried Expansion Joint

A.1.14 Other Elements

Figure A.41 – Superstructure Replacement

Arch removed, perhaps in mid twentieth century, possibly due to drainage works undermining the abutments or very poor condition of arch under carriageway. Abutment replacement and concrete trough unit type beam/slab deck used. Does not appear to be showing any signs of structural distress

Figure A.42 – Bridge Extension

Bridge extension. Masonry arch extended by in-situ concrete slab, usually carried out for road widening. In this case both sides of road were widened. Depending on the period of the extension works the concrete portion might well be under designed when subject to current assessment code loads.

Figure A.43 – Services Causing Damage

Figure A.44 – Pipe Smashed through Arch, poor repair work, if any.

Figure A.45 – Inconsiderate treatment of Protected Bridge by service designers and installers.

Localised damage to parapet.

APPENDIX B

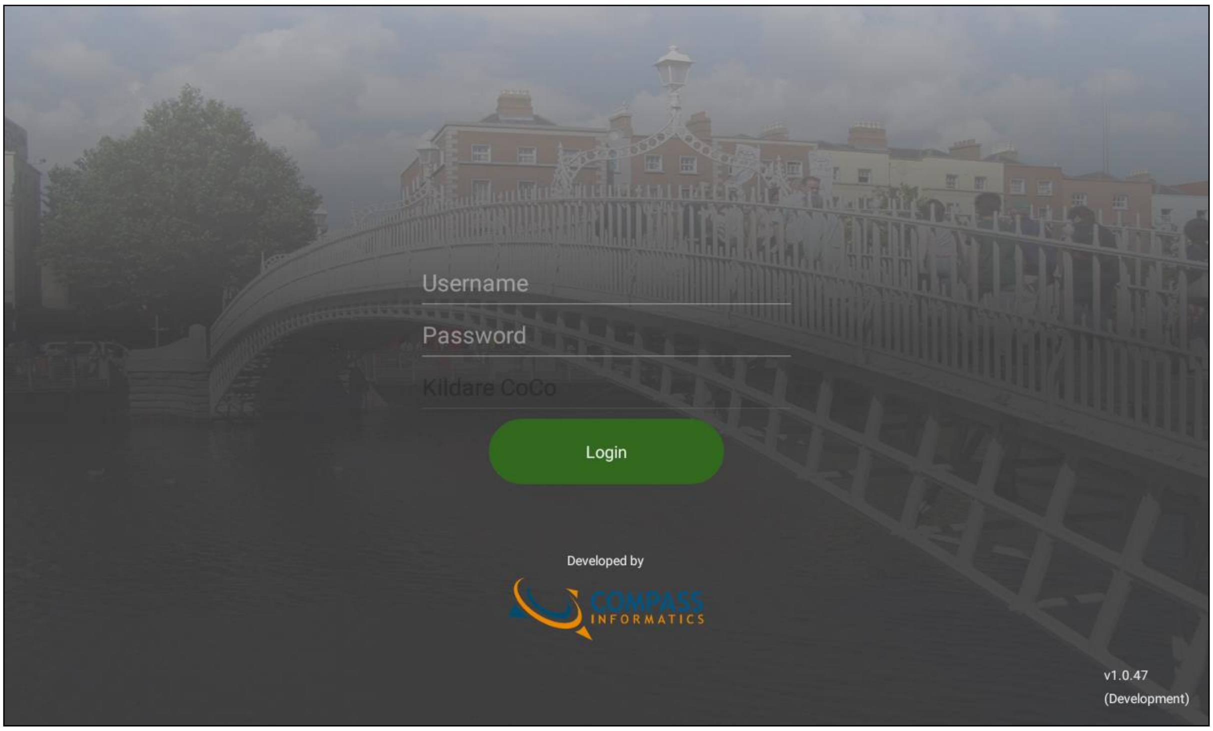
APPLICATION USER GUIDE

B APPENDIX B – APPLICATION USER GUIDE

This section provides guidance in using the application for all sections of the Bridge Asset Management System. The application can be used to carry out a Bridge Inventory Survey, a Maintenance Inspection and an Engineering Inspection. The application can only be used by authorised users, credentials will be supplied to those users by the Local Government Management Agency.

B1 Login

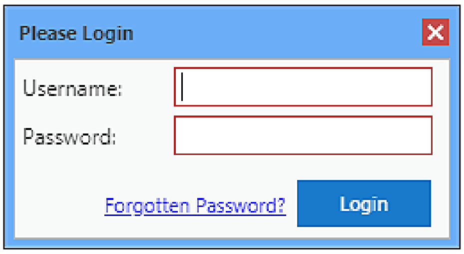
Tap on the Bridges App icon and login with your PMS username and password. The first time you login you will be asked to choose your Local Authority from the drop down list.



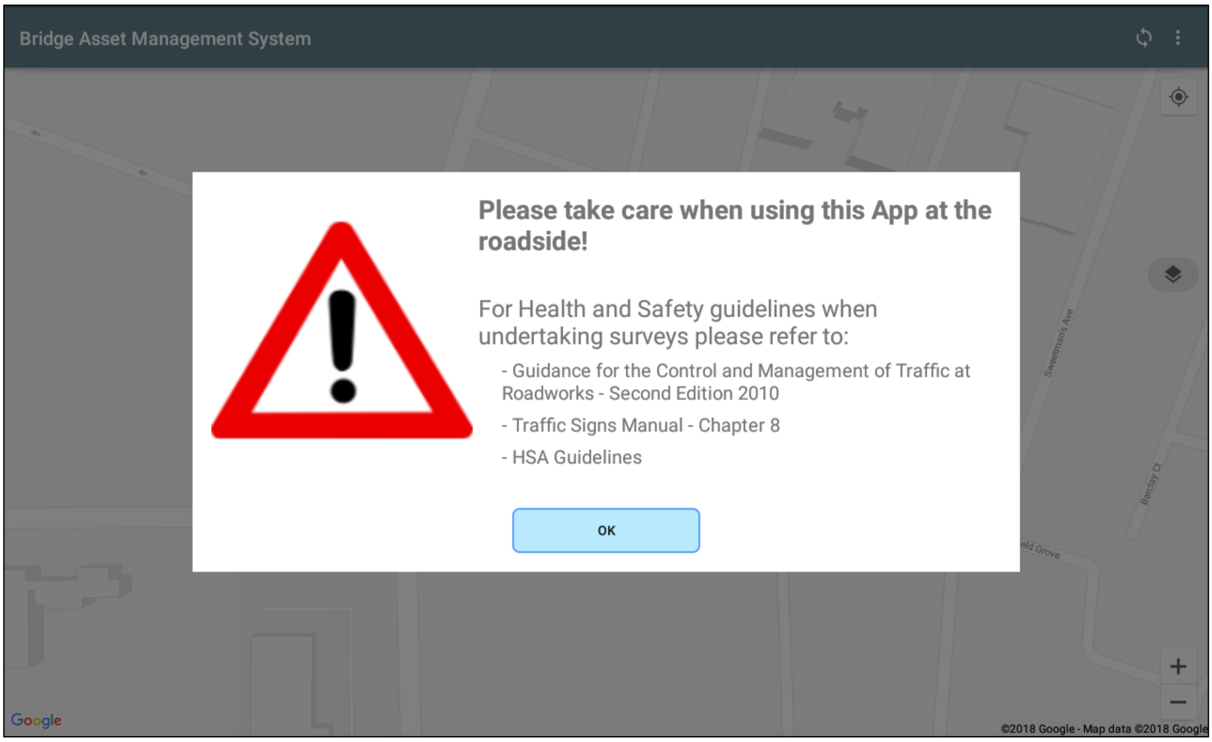
Note: The version number of the Bridges App is located in the bottom right corner of the login screen and this may be required during any support call. If you forget your PMS password it can be reset via the PMS (Browser) application.

Click on the PMS Log In button 

located in the bottom right corner and on the pop-up dialog box click the Forgotten Password link and follow the instructions to reset your password.



As part of the login process you will be presented with Health and Safety guidelines. The user should review this message and then confirm by pressing the OK button.



B2 Set-Up

When you login to the Bridges App for the first time you will notice a series of messages on screen as the local database is being set-up and the relevant data downloaded from the Pavement Management System (PMS). Depending on your connection speed this set-up should take between 30 and 60 seconds.

B3 Bridges Asset Management System - Home Screen

Once you have logged in and set-up has been successfully you will be presented with a map interface. Your current location will be marked by a blue dot at the centre of the map.

Note: If the Location service (GPS) on your Tablet is turned off you will be presented with the following message after you login:

Location is not available or enabled.

If you see this message you will need to enable the Location service (GPS) because the Bridges App will not function without this service. The Location service can normally be located in the Settings panel.

B4 Map Functions

There are several map functions available as icons on the right-side of the map.

- Zoom to Location: This icon can be used to centre your location on the map.
- Map Layers: The layers icon can be used to switch between the map layer (default) and satellite imagery.
- Zoom Options: The zoom icons allow a user to zoom in and out of the map. Zooming in and out (pinch-zoom) using your fingers is however a more useful option. Also, double tap with one finger to zoom in and tap once with two fingers to zoom out.

B5 Menu Options

Tap on the three dots in the top right corner to reveal the menu options.

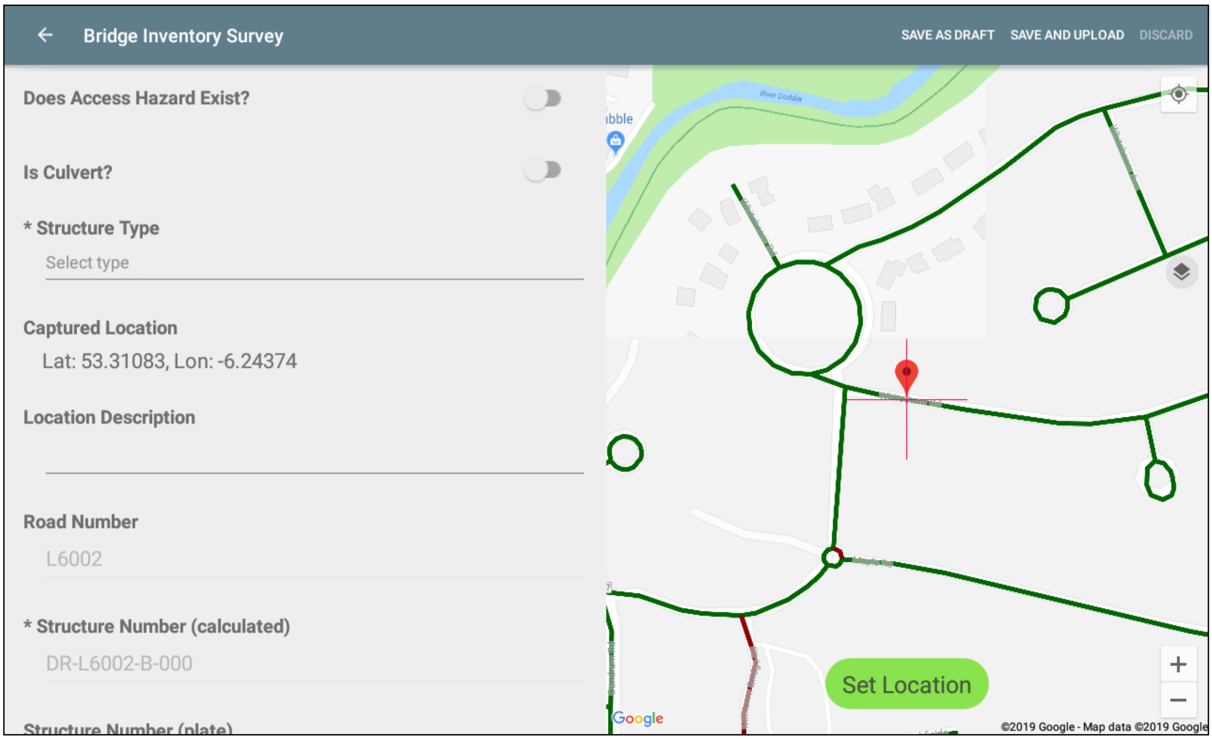
- **Add Bridge:** Choose this option to create a Bridge Inventory Survey (BIS).
- **Switch to OSi Map:** Choose this option to display the more detailed MapGenie mapping from the Ordnance Survey of Ireland.

- **Settings:** The Settings options allow you to decide if the Intersections Layer is displayed by default. You can also choose if the default mapping displayed is from Google or the OSi.
  - ∴ Please note the Intersections Layer of points will appear as you zoom in on the map
- Logout: When you are finished with the Bridges App you can use this menu option to logout or you can simply close the application.

B6 Bridge Inventory Survey (BIS) - Create

From the menu choose the **Add Bridge** option. You will be presented with a screen split into an attributes panel (left-side) and a map panel (right-side). The map will display your current location (assuming your Location service is active). If you need to adjust the location of the Bridge or Culvert, move the background mapping to align with the red crosshair. Once you are satisfied with the intended location press the green **Set Location** button.

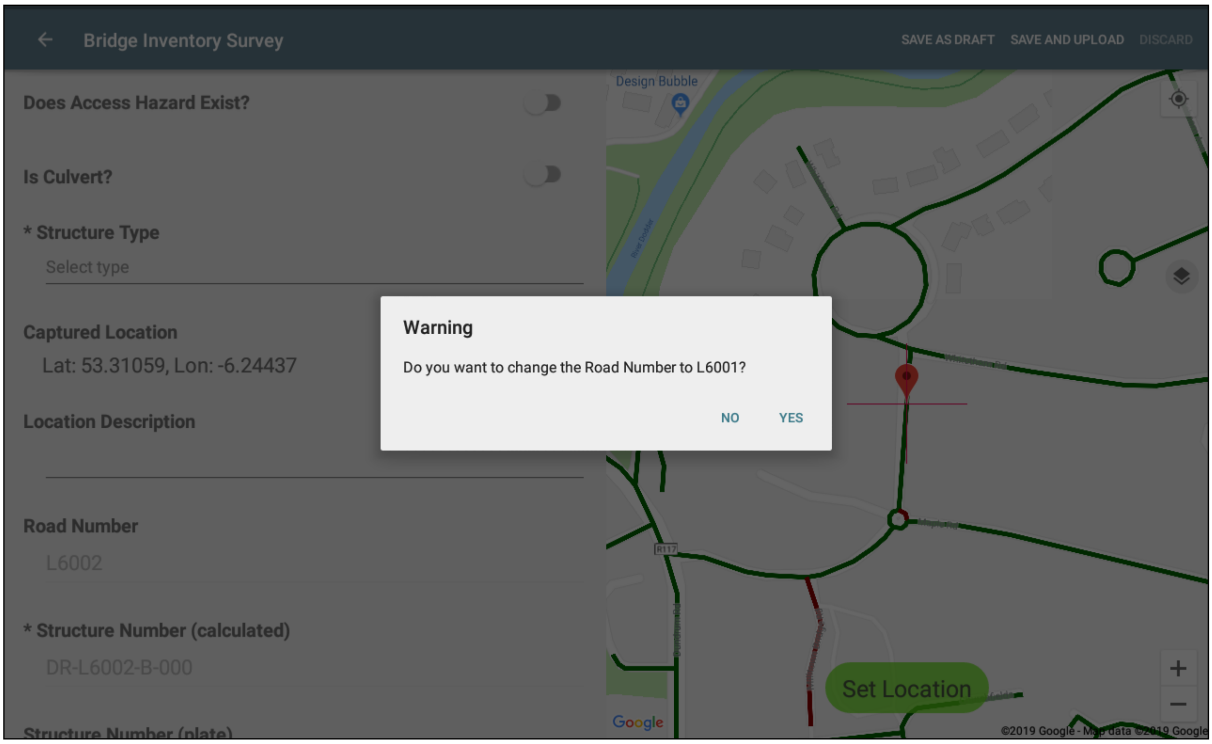
You will notice a selection of roads will display on the map and a red marker is used to identify the set location. The roads are displayed to guide the user in case location adjustments need to be made.



Note: Roads coloured green are in-charge by the local authority and roads coloured red are not in-charge. This information comes from the Pavement Management System (PMS).

Once you have set the location you will notice in the attributes panel that the **Captured Location** field has been updated with the Latitude and Longitude co-ordinates. In addition, the **Road Number** field has been updated to display the local road number e.g. L50122. The **Structure Number (calculated)** field is auto-populated once the location of the Bridge or Culvert has been set.

For example**, DR-L50122-B-00** is used to number a Bridge in Dun Laoghaire\Rathdown located on local road L50122. The 00 number indicates that this is the first Bridge captured on this road using the Bridges App. Please note you can set the location multiple times and if you re-set the location on a new road you will be asked to confirm the change.



The attributes on the following pages can be captured as part of a Bridge Inventory Survey (BIS); mandatory attributes are marked with an * asterix.

Does Access Hazard Exist?

If an access hazard or hazards exist, please select the button to reveal a list of hazards. A user can choose one or many hazards.

Is Culvert?

The default option is Bridge but if the structure is a Culvert choose this option. You will notice that the Structure Number (calculated) changes from B to C - i.e. from **DR-L50122-B-00** to **DR-L50122-C-00**.

*Structure or Culvert Type:

Select this field and choose the Bridge Type from the list e.g. Arch, Beam etc. If the '**Is Culvert**' option was selected then the user can choose a Culvert Type from the list such as Square or Round.

Captured Location:

This field is auto-populated with the Latitude and Longitude co-ordinates of the structure once the Set Location button on the map is selected.

Location Description:

This is an optional field and up to 300 characters can be entered to describe the location. As you type you will notice a character counter i.e. (55/300).

Road Number:

This field is auto-populated with the Road Number once the **Set Location** button on the map is selected e.g. L50122.

*Structure Number (calculated):

This field is auto-populated with the calculated Structure Number once the **Set Location** button on the map is selected e.g. DR-L50122-B-00.

Structure Number (plate):

This field is optional and is used to enter the plate number found physically located on most local and regional Bridges.

Structure Name (alias):

This field is optional and is used to capture the local name of a Bridge e.g. Five Mile Bridge.

*Structure Material:

It is a mandatory requirement to select at least one material from the list of options. One, many or all options can be selected using the relevant buttons.

*No. of Spans:

The Number of Spans is a mandatory field. Once selected a pop-up numeric window will be displayed allowing the user to enter the required number. Once completed, select the ‘**Done**’ button to close the pop-up window.

***Total Span (m):**

This is a mandatory field and once selected a pop-up numeric window will be displayed allowing the user to enter the required number.

***Structure Length (m):**

This is a mandatory field and once selected a pop-up numeric window will be displayed allowing the user to enter the required number.

***Structure Width (m):**

This is a mandatory field and once selected a pop-up numeric window will be displayed allowing the user to enter the required number.

Principal Function:

The default option for this field is **Public Road**. However, selecting this field will reveal other options such as Footway, Cycleway and Other.

Structure Over:

Select this field to reveal a list of options including Canal and Railway. It is a requirement to choose an option from either the Structure Over or Structure Under fields. You can’t choose from both fields, it’s an **either\or** option so the user will need to decide if the Bridge or Culvert is a structure ‘over’ or a structure ‘under’.

Structure Under:

Similar to the ‘Structure Over’ field, select this field to reveal a list of options. If you have completed the Structure Over field, then there is no need to complete this field and vice-versa.

***Height of Opening (m):**

This is a mandatory field and once selected a pop-up numeric window will be displayed allowing the user to enter the required number.

Is in Skew?

If the Bridge is in Skew, select this option and enter a value between 0 and 90 (Skew Angle). Any value over 90 will be rejected and will stop you uploading the data to the Pavement Management System (PMS).

Restricted Height/Clearance (as surveyed) (m):

This is an optional field and once selected a pop-up numeric window will be displayed allowing the user to enter the required number.

Is Warning/Regulatory Sign Present?

This is an optional field and once selected a numeric value needs to be entered into the **Value Displayed on Signage** (m) field.

Is Weight Restriction Present?

This is an optional field and once selected a numeric value needs to be entered into the **Weight Restriction (tonnes)** field.

Services Evident:

This is optional and simply requires the button to be selected if services are visible on the structure in question. No other input is required.

Photos:

At least one photo must be taken and up to a maximum of four. Select the **Add Photo** button. This will open the camera application on your Tablet. Capture the image in question and then choose the **OK** option. You can also choose the **RETRY** option and re-take the photo.

Once captured the photos are displayed as thumbnail images and are named using date and time. If you tap on a thumbnail image it will open a higher resolution version of that image. If you wish to delete the photo, select the Delete button to the right of the image.

Tip: Ideally, the first image you take should be the 'headshot' or image that best captures all aspects of the structure

B6.1 BIS - Save As Draft

You can save a Bridge Inventory Survey (BIS) as a draft by choosing the **SAVE AS DRAFT** option in the top right corner. This option might be chosen if a user has not yet completed the BIS and wants to return to it at a later date. Completed BIS can also be saved as draft and reviewed prior to upload. Once saved as a draft, the BIS in question will appear on the map with a blue marker. Tapping on this blue marker will reveal the calculated name of the BIS e.g. DR-L50122-B-00 (Draft BIS).

Bridge Inventory Surveys saved as draft are stored locally on the Tablet and are not uploaded to the Pavement Management System. Thus, a user needs to be mindful of this in case the Tablet in questions gets lost or fails in some way. Draft BIS should only be stored on the Tablet for a short period of time.

Note: A Bridge Inventory Survey can be saved as a draft without having to complete all mandatory fields. However, when the BIS is finally uploaded to PMS all mandatory fields must be completed. If they are not completed the upload is rejected and the user will be informed of what mandatory data is missing.

B6.2 BIS - Save and Upload

To upload a BIS to the Pavement Management System (PMS) simply complete all mandatory fields and choose the **SAVE AND UPLOAD** option in the top right corner. You will be asked if you want to save and upload the changes. Selecting the **YES** option will upload the BIS data to PMS. If you have not completed all mandatory fields, you will be presented will alerts on the screen. For example:

Warning – Inventory Survey cannot be saved as it is not valid. Structure Type is not set!

This warning message will be presented to the user if a **Structure Type** has not been selected. Ensure all mandatory fields have been completed and at least one photo captured before uploading a BIS to PMS. During the upload process the user will notice several messages on screen. Depending on the connection speed the upload process should take between 30 and 60 seconds. If the Tablet is offline during the upload process the user will be presented with the following alert:

Sync Failed! No Internet Access!

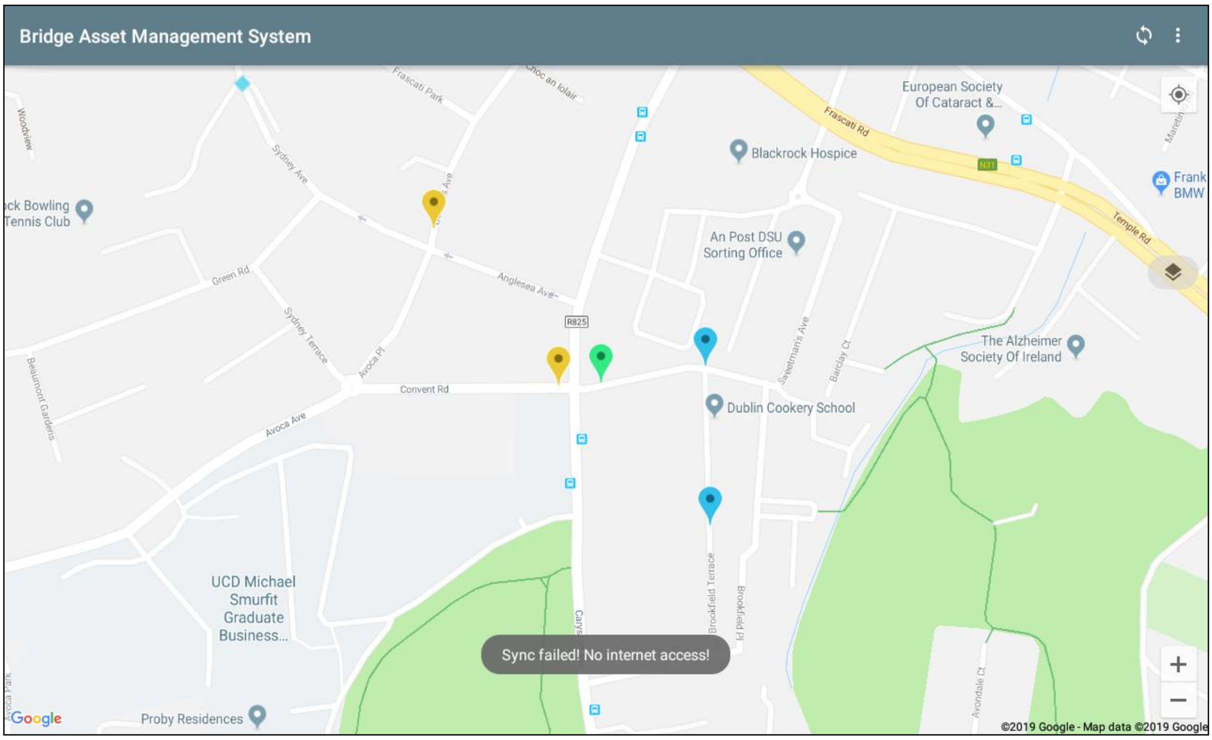
As a result, the BIS will be queued on the Tablet and will upload once an internet connection becomes available. Bridge Inventory Surveys that have not uploaded to PMS are presented on the map using orange markers.

B6.3 BIS - Discard

If a user does not want to upload a draft BIS to PMS they can select the draft BIS in question from the map (blue marker) and once it loads the user can select the Discard option in the top right corner. This will delete the draft BIS from the Bridges App.

B6.4 Surveys - Management and Information (Metadata)

When a user logs into the Bridges App they are presented with a map interface. The map interface may contain three different coloured markers.



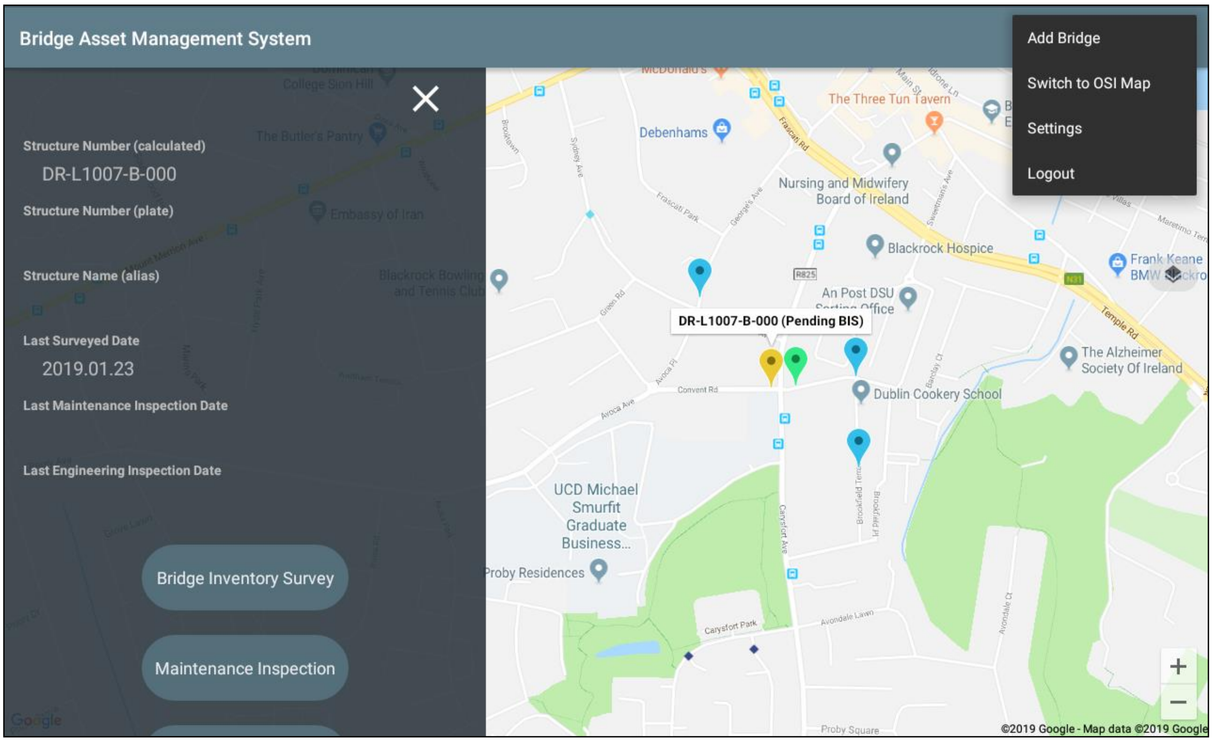
BLUE MARKERS: These markers indicate that a Survey has been saved as a draft. Tapping on the blue marker on the map will display a tooltip that will indicate if the draft survey is a Bridge Inventory Survey (BIS), Maintenance Inspection (MI) or Engineering Inspection (EI).

GREEN MARKERS: These markers indicate that a BIS, MI or EI has been successfully uploaded to the Pavement Management System. Tapping on the green marker in question will display an information panel on the left-side. This panel displays information such as Structure Number (calculated) and Structure Name (alias). However more importantly this information panel shows the **Last Survey Date** which indicates when a Basic Inventory Survey (BIS) for the structure in question was created or when it was last updated. The information panel also shows if a Maintenance Inspection (MI) or Engineering Inspection (EI) exists for the structure in question and if they do exist when these surveys were created i.e. Last Maintenance Inspection Date and Last Engineering Inspection Date.

Orange Markers: These markers simply indicate that a BIS, MI or EI has not been successfully uploaded to the PMS. This is most likely because of no internet connection. Once internet connection has been restored to the Tablet these surveys will be uploaded to PMS.

B7 Maintenance Inspection (MI)

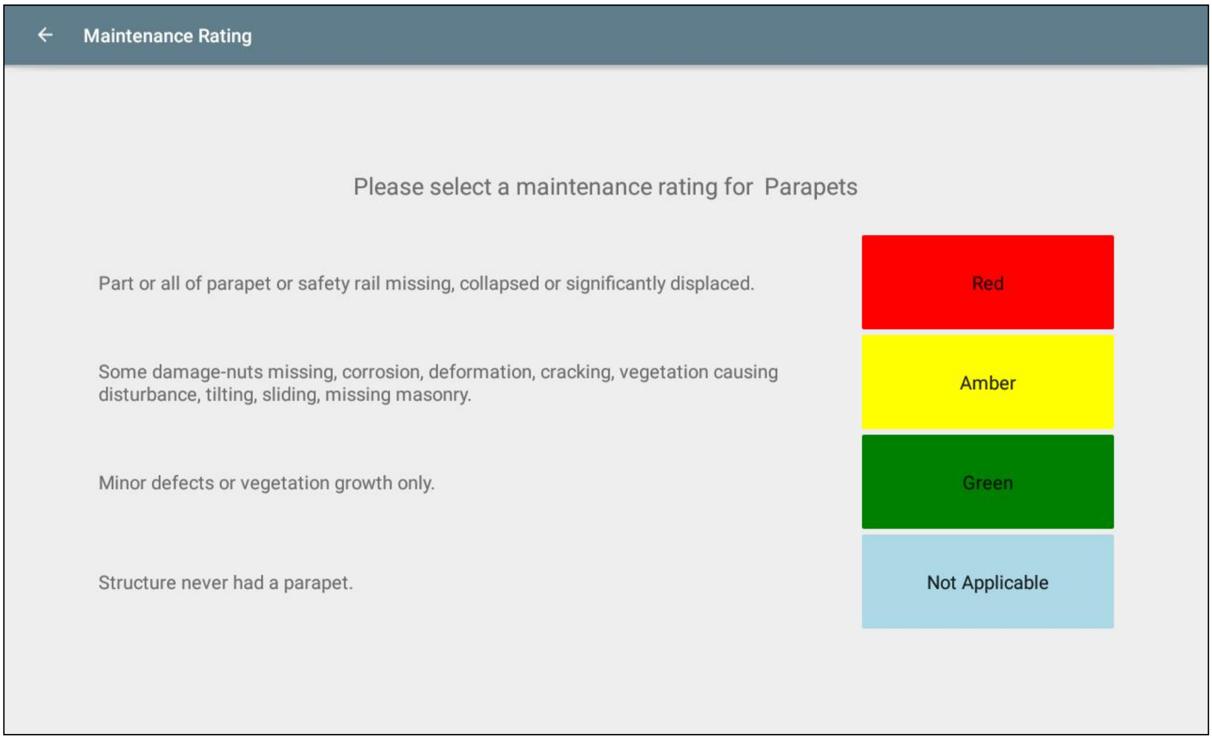
You must create a Basic Inventory Survey (BIS) for a Bridge or Culvert before you can undertake a Maintenance Inspection (MI). If a Basic Inventory Survey exists for a structure, simply tap on the green marker in question from within the map to reveal the information panel for that structure. You will notice that the Basic Inventory Survey button is visible as are the Maintenance Inspection and Engineering Inspection Buttons.



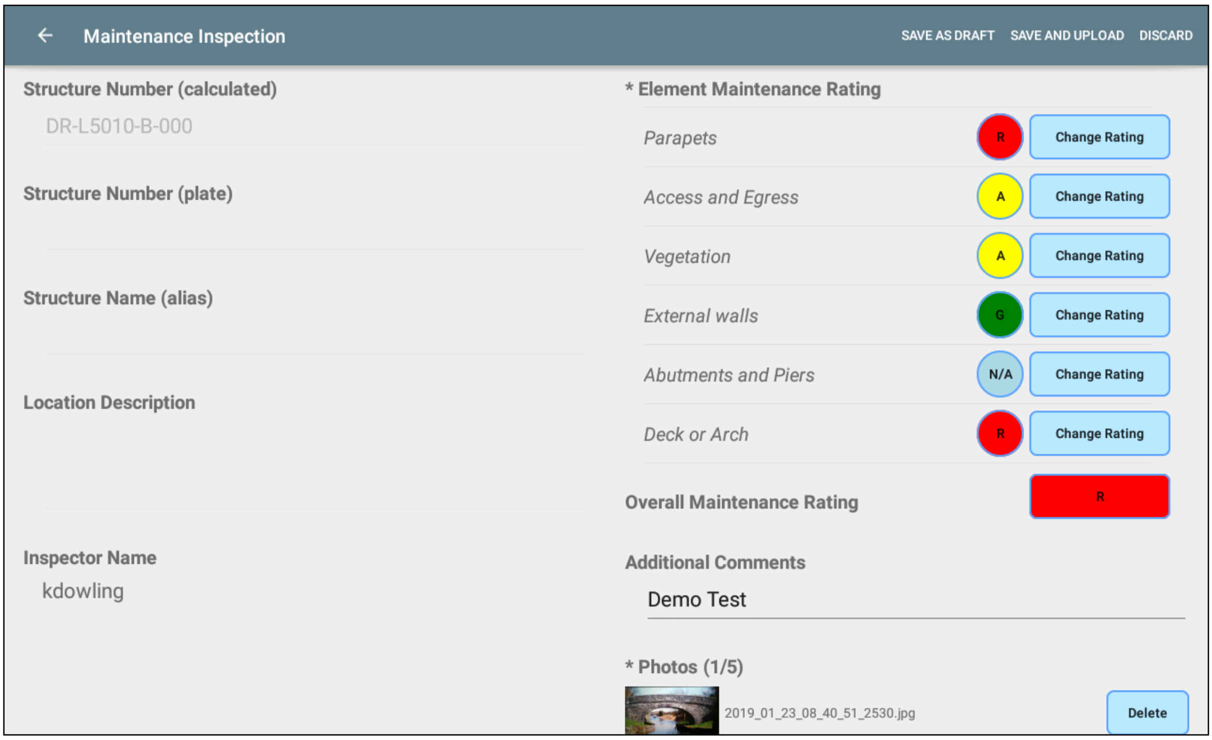
Note: In some cases, a user may not have the required permission to undertake an MI or EI and as a result these buttons will appear greyed out and inactive.

To create an MI the user can simply select the Maintenance Inspection button to load the screen. The left side of the screen shows information such as the Structure Number (calculated) and the inspector's name, based on the PMS login. On the right side there are six inspection elements such as Parapets, Vegetation and External Walls. All six elements are mandatory. A user will select the **Change Rating** button and that will display a screen where the user is asked to **select a maintenance rating** for the element in question by choosing Red, Amber, Green or Not Applicable.

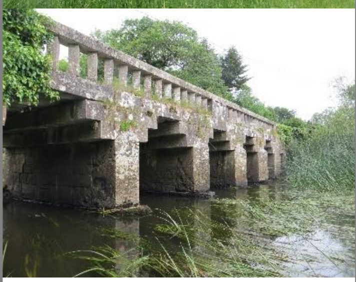
A text description is provided beside each option in order to guide the user. Selecting an option closes the screen and updates the colour option beside the maintenance element e.g. if Red was chosen then a red coloured circle is displayed beside the maintenance element.

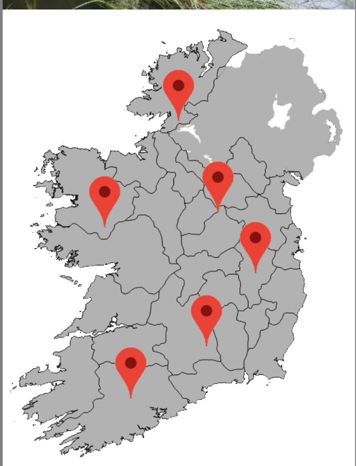


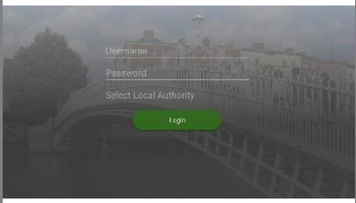
Once all six elements have been rated an **Overall Maintenance Rating** is auto-calculated based on the user's choices. Additional comments can be added by the user and up to five photos can be captured. Similar to the BIS, at least one photo must be captured for the MI.



Once all the mandatory information has been captured, the survey in question can be saved as a draft or uploaded directly to PMS by selecting the **SAVE AND UPLOAD** option.







An Roinn Iompair,
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Department of Transport, Tourism and Sport,
Leeson Lane,
Dublin 2,
Ireland
D02 TR60

Web: www.dttas.gov.ie
e-Mail: info@dttas.gov.ie
Tel: LoCall 0761 001 601
or +353 1 670 7444

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