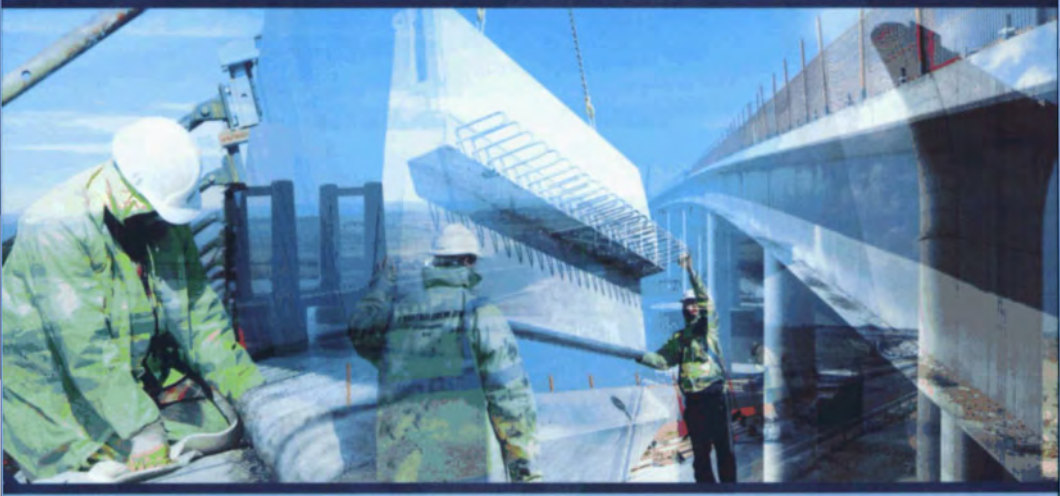
INSPECTION MANUAL
FOR HIGHWAY STRUCTURES



VOLUME 2: INSPECTOR'S HANDBOOK MAY 2007

Inspection Manual for Highway Structures

Volume 2: Inspector's Handbook

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Foreword

by Ginny Clarke, Chief Highway Engineer – Highways Agency

Inspections play a vital role in the effective management of highway structures ensuring that our highway assets are safe for use and fit for purpose. This document, comprising two complementary Volumes, has been produced to assist engineers and inspectors with this task and draws together a wealth of experience and knowledge reflecting current best practice in the United Kingdom, superseding the Bridge Inspection Guide 'Yellow Book', which has served us well for many years.

The manual reflects a very successful collaboration with other highway authorities, owners, interested bodies and the supply chain and I would like to thank all those who have contributed to its drafting, review and publication.

Ginny Clarke
Chief Highway Engineer – Highways Agency

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Summary

It is widely recognised that a well managed transport infrastructure is vital to the economic stability, growth, and social well being of a country. Bridges and other highway structures are fundamental to the transport infrastructure because they form essential links in the highway network. They are relied upon to remain in service year after year, carrying ever-increasing traffic flows, while being managed in a manner that ensures they are Safe for Use and Fit for Purpose.

The majority of highway structures are managed and maintained at public expense. It is therefore important that their management minimises disruption, risk and consequential costs to road users, and makes economic and efficient use of resources. Fundamental to effective management is an inspection regime that provides timely, accurate and appropriately detailed information on asset condition and performance. The overall purpose of inspection, testing and monitoring is to check that highway structures are Safe for Use and Fit for Purpose and to provide the data required to support effective maintenance management and planning.

The purpose of this Inspection Manual is to provide guidance on the inspection process for all staff involved in the management of highway structures. It is also considered that this Manual provides a sound basis for the development of formal inspector training courses.

This Manual aims to ensure that inspections are carried out efficiently, uniformly and to a high standard. The Manual is intended for use as guidance, outlining typical procedures and defining the normal requirements for the various categories of inspection. It is not intended to provide the definitive solution in all situations, as the party best able to decide on the appropriate course of action is the inspector or engineer undertaking the work.

The Manual is divided into two separate but complementary Volumes. Each of the two Volumes is sub-divided into several Parts that provide guidance on a wide range of issues as listed below.

- ***Volume 1: Reference Manual*** – covers all aspects of highway structures inspection that both inspectors and engineers should be aware of.
  - *Part A. Introduction and Implementation*: Provides an overview of the Manual; includes an introduction to the role and need for the Manual, describes the purpose, objectives and scope of the Manual and how it should be implemented. It also offers an overview of the inspection regime and summarises the general competence and training requirements for inspection staff.
  - *Part B. Behaviour of Structures*: Provides inspectors with an overview of the engineering topics that they should be aware of and offers a consistent basis for inspector knowledge development and training. It contains a summary of topics such as structural mechanics, structural materials and their properties, common types of highway structures and structural elements. It aims to provide organisations with a check list of criteria they should include on training courses but does not provide detailed coverage of the topics.
  - *Part C. The Inspection Process*: Provides general information on scheduling inspections, planning and preparing for inspections, access considerations, health and safety aspects, and advice on performing inspections on differing types of structures.
  - *Part D. Defect Descriptions and Causes*: Provides background information and guidance on describing and categorising defects. It describes the principal defects that are likely to be encountered in concrete structures, metal and metal/concrete composite structures, masonry structures, and structures built from other materials, with the emphasis placed on identification and likely causes.

- *Part E. Investigation and Testing*: Summarises a wide range of testing methods available for highway structures, including tests for material properties, defects and causes of defects. This aims to make inspection staff aware of the tests that may be used to inform management.
- *Part F. Appendices*: Contains a selection of information which collectively support the guidance provided in Parts A to E.

- ***Volume 2: Inspector's Handbook*** – acts as a quick reference for inspectors on site.
  - *Part A. Inspector's Guide*: Highlights the key points from Volume 1 that inspectors should be aware of before, during and after undertaking inspections. Cross-references to Volume 1 are provided, enabling inspectors to quickly look up more detailed advice or guidance as and when required.
  - *Part B. Defect Photographs*: Provides a library of photographs illustrating the different types of defects that are likely to be encountered on highway structures.

Acronyms and Abbreviations

CDM	The Construction (Design and Management) Regulations
MEWP	Mobile Elevating Work Platform
PPE	Personal Protective Equipment
TSA	Thaumasite Sulphate Attack
§	Section(s)
¶	Paragraph(s)

Part A
Inspector's Guide

This Part highlights and cross-references the key points from Volume 1 that inspectors should be aware of before, during and after undertaking inspections. Cross-references to Volume 1 are provided to enable inspectors to quickly look up more detailed advice or guidance as and when required.

1 Introduction

1.1 OVERVIEW OF THE INSPECTION PROCESS

1.1.1 The overall purpose of inspection, testing and monitoring is to check that highway structures are safe for use and fit for purpose and to provide the data required to support effective maintenance management and planning (see Volume 1: Part A: Section 1.2). In order to achieve this, a rational five step approach, illustrated in Figure A.1, is recommended for the development and delivery of a robust inspection regime.

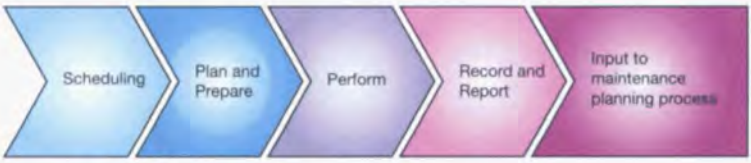


Figure A.1 – The inspection process

1.1.2 It is unlikely that inspectors will be involved in all parts of the process illustrated in Figure A.1; however they should have a sound understanding of the overall process.

1.2 LAYOUT OF PART A

1.2.1 This Part of the Manual seeks to provide a concise overview of the inspection process, containing cross-references to Volume 1 that enable inspectors to look up more detailed advice or guidance as and when required. This is provided in the form of two summary tables:

- Section 2: Work Packages – divides the inspection process into a number of distinct, but interrelated, work packages.
- Section 3: Guidance and Cross-references – provides high level guidance for each for the Work Packages and cross-references to more detailed guidance in Volume 1.

1.2.2 The guidance provided in this handbook does not provide sufficient detail to enable inspection staff to undertake safe, effective and efficient inspections. This handbook must be used in conjunction with Volume 1 and supplemented by appropriate inspector training.

2 Work Packages

2.1.1 The following table presents the typical packages of work that make up the inspection process. The order in which the Work Packages are presented is considered to represent a logical and practical approach for the inspection process; however, this should be reviewed by authorities and, where appropriate, tailored to their specific working practices and requirements. The 'ID' column refers to the guidance and cross-references given in Section 3.

Topic	Description	ID
Method Statement	A method statement that summarises the safest method of working should be prepared. All other relevant information should also be prepared and agreed before undertaking an inspection.	1-5
Health and Safety	Due consideration should be given to minimising health and safety risks to people, including the public and others who may be affected by the work activities, as well as those actually carrying out the work.	6-18
Risk Assessment	A risk assessment that identifies and records the measures to be taken to eliminate or reduce risks to inspection personnel and to the public during the proposed activity should be carried out.	19-23

Topic	Description	ID
Methods of Access	Careful thought should be given to how access will be gained to the required parts of the structure.	24-35
Equipment Needed	It is essential that the inspector is appropriately equipped for the type of inspection to be undertaken and that the equipment required is available and is functioning correctly.	36-46
Structure Records	The number and type of records to be reviewed would depend on availability and the nature of the inspection, but should generally cover the appropriate records held in the Health and Safety File.	47-48
Testing	If site testing is required as part of the inspection, then a suitable programme of testing should be developed.	49-53
Inspection Staff	All inspections should be undertaken by personnel that are judged by the Supervising Engineer to satisfy the minimum health, experience and, where appropriate, qualification requirements for the particular inspection type.	54-57
Work Notification	There may be a need to notify other parties and, in some cases, obtain their approval for the proposed inspection.	58-62

Topic	Description	ID
Environmental Impacts	Consideration should be given to whether the work is likely to have any environmental impacts and, if so, seek expert advice to identify and implement the appropriate working practices and/or mitigation measures.	63-72
Arrival on Site	The team leader should brief the inspection team. Attention should be paid to avoid inspecting the wrong structure by mistake.	73-77
Before Commencing Work	It is advisable to check and ensure that the required safety, traffic management and access arrangements are in place and operate satisfactorily.	78-84
Undertaking Inspections	Inspections should be carried out in a logical and systematic manner to the full requirements of the specific inspection brief but without compromising safety.	85-94
Recording Inspection Findings	Any observed defects along with their associated severity and extent should be recorded on an appropriate inspection pro-forma.	95-96
Before Leaving the Site	The inspection team should verify that all the information required has been captured and that the site is thoroughly clear of all inspection equipment and materials	97-100

Topic	Description	ID
Back In the Office	The principal information obtained from all inspections should be appropriately stored, for example, on a computerised system. The inspection findings should be evaluated to identify urgent actions and future maintenance needs.	101-106

3 Guidance and Cross-References

3.1.1 The following table provides guidance on the considerations and activities related to each Work Package outlined in Section 2. Cross-references to Volume 1 are provided against each item, enabling more detailed advice or guidance to be looked-up as and when required. The following symbols are used to summarise the actions required:

- DR – Document review
- DP – Document preparation
- DS – Document storage
- SEA – Seek agreement/advice from the Supervising Engineer
- SOA – If expertise is lacking, seek agreement or advice from the authority's Safety Officer
- SpA – Specialist support or advice may be required
- TPNA – Third party notification/agreement
- EqR – Equipment required
- EqC – Equipment serviceability checked
- ⓘ – Information or Warning

3.1.2 The following abbreviations are also used:

- § – Section(s)
- ¶ – paragraph(s)

3.1.3 Authorities may wish to use the following as a generic checklist of activities that should be undertaken during the inspection process. However, it is important to tailor the following to reflect any authority specific working practices and to be proportional to the scope, detail and needs of the particular inspection and structure type.

	ID	Guidance	Volume 1	Action
Method Statement	1	Consult the inspection schedule to find out what type of inspection is required.	Part C: § 2	DR
	2	Prepare a draft method statement (in conjunction with a risk assessment) that details the safest method of working.	Part C: § 3.2: ¶ 3.2.1	DP SOA
	3	Review and agree the draft method statement.	Part C: § 3.2: ¶ 3.2.1	DR SEA
	4	Retain a copy of the method statement in the structure Health and Safety file.	Part C: § 3.2: ¶ 3.2.2	DS
	5	Ensure that the entire inspection team is familiar with the agreed method statement.	Part C: § 3.2: ¶ 3.2.3	DR SEA

	ID	Guidance	Volume 1	Action
Health and Safety	6	Review the structure Health and Safety File.	Part C: § 3.7: ¶ 3.7.2	DR
	7	Check whether the work falls within the scope of CDM regulations.	Part C: § 3.3: ¶ 3.3.6	DR SEA
	8	Review the Asbestos Management Plan.	Part C: § 3.3: ¶ 3.3.7-3.3.8	DR SEA
	9	Consider personal safety matters and/or review personal safety checklist.	Part C: § 3.3: ¶ 3.3.9-3.3.20 & Part F: Appendix B	DR SOA
	10	Assess the benefits of night-time working to decide whether it is a safe and practicable option.	Part C: § 3.5: ¶ 3.5.55-3.5.61	SEA SpA
	11	If work will be carried out in or near water or in confined spaces, ensure that the entire inspection team is warned of the dangers of Leptospirosis (Weils Disease) and is familiar with the relevant control measures.	Part C: § 3.3: ¶ 3.3.18	SEA SOA
	12	A supply of soap, water and disposable paper towels is advised, in case there is contact with dirty surfaces.	Part C: § 3.3: ¶ 3.3.13	EqR

	ID	Guidance	Volume 1	Action
Health and Safety	13	A first aid kit appropriate for the number of staff and nature of likely injuries should be made available.	Part C: § 3.3: ¶ 3.3.13	EqR
	14	Ensure that the entire inspection team is aware of the procedures to be followed and people to contact in the event of an accident.	Part C: § 3.3: ¶ 3.3.20	SEA
	15	Ensure that any electrical equipment attached to structures is isolated or disconnected before carrying out inspections in the vicinity and note the locations of any nearby overhead lines.	Part C: § 3.3: ¶ 3.3.22-3.3.23	SEA SpA
	16	Consider the coverage of the inspector's mobile phone if the inspection involves entering 'remote areas'	Part C: § 3.5: ¶ 3.5.20	SEA SpA
	17	Ensure that excavation work is not undertaken without first checking for the presence of cables or other buried apparatus.	Part C: § 3.3: ¶ 3.3.24	DR SEA SpA
	18	Consider the safety of the public and other third parties.	Part C: § 3.3: ¶ 3.3.26-3.3.29 & Part C: § 3.5: ¶ 3.5.44	SEA

	ID	Guidance	Volume 1	Action
Risk Assessment	19	Prepare a draft risk assessment, identifying hazards and mitigation or control measures.	Part C: § 3.4 & Part C: § 3.5: ¶ 3.5.11, 3.5.32, 3.5.39, 3.5.51 & 3.5.57	DP SOA
	20	If appropriate, combine the risk assessment with other documents, such as the health and safety plan or method statement.	Part C: § 3.4: ¶ 3.4.11	DP SEA
	21	Review and agree the draft risk assessment.	Part C: § 3.4: ¶ 3.4.5 & 3.4.9	DR SEA
	22	Retain a copy of the risk assessment in the structure Health and Safety file.	Part C: § 3.2: ¶ 3.2.2	DS
	23	Ensure that the entire inspection team is familiar with the agreed risk assessment.	Part C: § 3.2: ¶ 3.2.3	SEA DR
Methods of Aceess	24	If work will be carried out on or near a highway, provide traffic management and, if necessary, diversionary routes for pedestrians.	Part C: § 3.5: ¶ 3.5.4-3.5.15	EqR SEA
	25	Where access requires traffic management on a road owned by another authority, consult the owner.	Part C: § 3.5: ¶ 3.5.7	EqR SEA TPNA

	ID	Guidance	Volume 1	Action
Methods of Aceess	26	If work will be carried out off the highway, seek permission for access from landowners or occupiers	Part C: § 3.5: ¶ 3.5.16-3.5.19	SEA TPNA
	27	If work will be carried out off the highway, take into account the requirements of vehicles, pedestrians and livestock that may use the area.	Part C: § 3.5: ¶ 3.5.17	EqR SEA TPNA
	28	If work will be carried out on or over railways, adhere to the procedures of the relevant railway authority.	Part C: § 3.5: ¶ 3.5.21-3.5.22	DR SEA
	29	If work will be carried out in or over water, ensure that it is undertaken by suitably experienced and qualified staff or specialist firms, as appropriate.	Part C: § 3.5: ¶ 3.5.23-3.5.30	SEA SpA
	30	If work will be carried out underwater, review all available information concerning underwater parts of the structure.	Part C: § 3.5: ¶ 3.5.31-3.5.33	DR
	31	Unless an underwater inspection is required urgently, consider timing it to coincide with favourable conditions such as low spring tides or low river flow.	Part C: § 3.5: ¶ 3.5.34	SEA

	ID	Guidance	Volume 1	Action
Methods of Aceess	32	If an underwater inspection is required, consider lowering the water level or diverting the watercourse, but do not disregard the associated environmental implications.	Part C: § 3.5: ¶ 3.5.35-3.3.36	EqR SEA SpA
	33	If diving operations will be required, ensure that these are carried out by suitably qualified and experienced personnel.	Part C: § 3.5: ¶ 3.5.37-3.3.41	SEA SpA
	34	If diving contractors will be employed to undertake underwater inspectors, ensure that a job specific diving plan and a separate risk assessment for non-diving operations are prepared.	Part C: § 3.5: ¶ 3.5.39	DP SEA SOA SpA
	35	If work will be carried out in a confined space, prepare a permit to work/enter system.	Part C: § 3.5: ¶ 3.5.48-3.5.54 & Part F: Appendix C	DP SEA SOA SpA

	ID	Guidance	Volume 1	Action
Equipment Needed	36	Determine what type of access equipment is required, how the equipment will be transported to and from the site and whether there are any restrictions or obstructions.	Part C: § 3.6: ¶ 3.6.1-3.6.27	EqR SEA SpA
	37	If scaffolding is used, ensure that it is erected, altered or dismantled by adequately trained and experienced persons.	Part C: § 3.6: ¶ 3.6.12	EqR
	38	Ensure that barriers or warning devices are placed around the base of a scaffold to prevent collision either by vehicles or pedestrians.	Part C: § 3.6: ¶ 3.6.12	EqR
	39	If MEWPs are used, they should be operated and checked for serviceability by suitably experienced and qualified personnel.	Part C: § 3.6: ¶ 3.6.16-3.6.18	EqR EqC SpA
	40	If a MEWP is used, ensure that the work platform is fitted with clearly marked safety harness attachment points that are sufficient for the number of persons that will be carried.	Part C: § 3.6: ¶ 3.6.19	EqR

	ID	Guidance	Volume 1	Action
Equipment Needed	41	If abseiling is required, it must only be undertaken by specially trained and experienced firms.	Part C: § 3.6: ¶ 3.6.22-3.6.23	SEA SpA
	42	Ensure that permanently installed access equipment has been appropriately maintained and is safe for use.	Part C: § 3.6: ¶ 3.6.25-3.6.27	SpA EqC SEA
	43	If present, do not use permanently installed access equipment unless appropriately experienced and trained.	Part C: § 3.6: ¶ 3.6.26	ⓘ
	44	Determine what PPE is required, ensure it is available and that it has been maintained as recommended by the manufacturers.	Part C: § 3.6: ¶ 3.6.28-3.6.30	EqR EqC SEA
	45	Determine what type of data recording equipment is required and ensure it is available and operational.	Part C: § 3.6: ¶ 3.6.31-3.6.34	EqR EqC SEA
	46	Determine what type of measuring equipment is required and ensure it is available and operational.	Part C: § 3.6: ¶ 3.6.35	EqR EqC SEA

	ID	Guidance	Volume 1	Action
Structure Records	47	Review the structure records to obtain a thorough understanding of the characteristics of the structure and of any features or defects which may require special attention.	Part C: § 3.7	DR
	48	Particular attention should be paid on records of the methods of access and traffic management previously used as this will eliminate the need to plan the work from scratch.	Part C: § 3.7: ¶ 3.7.3	DR
Testing	49	Determine whether there is a need for testing.	Part C: § 3.8 & Part E: § 2.2	DR SEA
	50	Define and document the objectives of the testing operations.	Part E: § 2.2, ¶ 2.2.3-2.2.4	DP SEA
	51	Identify alternative testing options	Part E: § 2.2, ¶ 2.2.5	SEA SpA
	52	Appraise and compare the identified testing options and select the most appropriate solution.	Part E: § 2.2, ¶ 2.2.6-2.2.8	DP SEA SpA
	53	Plan testing operations, i.e. the range and location of tests, and their extent and intensity, to suit the specific objectives.	Part C: § 3.8, Part E: § 2.2	DP SEA SpA

	ID	Guidance	Volume 1	Action
Inspection Staff	54	At least one experienced inspector should always be present on site during an inspection.	Part A: § 4.2 & Part C: § 3.9	SEA
	55	Inspectors should be in sound health and have a realistic appreciation of their own limits of experience and ability.	Part A: § 4.2 & Part C: § 3.9	SEA
	56	Inspectors with limited experience should work under the supervision of experienced staff.	Part A: § 4.2 & Part C: § 3.9	SEA
	57	If work at night is planned, ensure that sufficient resources are provided to complete the work so that the road can be reopened by the due time.	Part C: § 3.5: ¶ 3.5.55-3.5.61	SEA
Work Notification	58	If access will be required to land under different ownership, at or adjacent to the highway structure, obtain access permission from any landowners, tenants and/or occupiers.	Part C: § 3.5: ¶ 3.5.16-3.5.20 & Part C: § 3.10: ¶ 3.10.1	DR SEA TPNA
	59	If work will be carried out on or over railways, consult with the relevant authority to agree details of possessions and safe working practices.	Part C: § 3.5: ¶ 3.5.21-3.5.22 & Part C: § 3.10: ¶ 3.10.2	SEA TPNA

	ID	Guidance	Volume 1	Action
Work Notification	60	If work will be carried out adjacent to or over canals or navigable waterways, consult the relevant authority to find out if there are any special requirements.	Part C: § 3.5: ¶ 3.5.29 & Part C: § 3.10: ¶ 3.10.2	SEA TPNA
	61	Establish the presence of services in or near the highway structure and consult the service authorities for details.	Part C: § 3.3: ¶ 3.3.23-3.3.24 & Part C: § 3.10: ¶ 3.10.3	DR SEA TPNA
	62	Determine whether advanced publicity and/or prior notification of the works to the general public will be required.	Part C: § 3.5: ¶ 3.5.61, Part C: § 3.10: ¶ 3.10.5-3.10.6 & Part C: § 3.11: ¶ 3.11.3-3.11.4	SEA TPNA
Environmental Impacts	63	If work at night is planned near residential properties or other sensitive areas, consult the environmental health department of the relevant authority and obtain consent.	Part C: § 3.5: ¶ 3.5.61, Part C: § 3.10: ¶ 3.10.5 & Part C: § 3.11: ¶ 3.11.3-3.11.4	TPNA
	64	If work will be carried out on or near farmland, consider the requirements of livestock, e.g. access, timing, straying, etc.	Part C: § 3.5: ¶ 3.5.16-3.5.19	SEA TPNA

	ID	Guidance	Volume 1	Action
Environmental Impacts	65	If work will be carried out on or near farmland, adopt the necessary procedures so as to minimise any damage or disruption to crops, e.g. keep to arranged access routes to and from the highway structure site.	Part C: § 3.5: ¶ 3.5.16-3.5.19	SEA TPNA
	66	If it will be necessary to cross, or work on or adjacent to, agricultural land, adopt the necessary procedures to avoid the spread of animal or plant diseases.	Part C: § 3.5: ¶ 3.5.16-3.5.19	SEA TPNA
	67	Determine whether there are any protected habitats at or near the structure and if so develop suitable methods of working.	Part C: § 3.11: ¶ 3.11.22-3.11.24	DR SpA TPNA
	68	Adopt appropriate procedures to ensure that air and watercourse pollution is avoided.	Part C: § 3.11: ¶ 3.11.25-3.11.28	EqR
	69	Adopt the necessary procedures to avoid any damage or destruction of rare or protected plants.	Part C: § 3.11: ¶ 3.11.5-3.11.7 & 3.11.29-3.11.31	DR SpA
	70	Adopt the necessary procedures to avoid the disturbance of bats or their roosts in bridges.	Part C: § 3.11: ¶ 3.11.8-3.11.13 & 3.11.29-3.11.31	DR SpA

	ID	Guidance	Volume 1	Action
Environmental Impacts	71	Adopt the necessary procedures to avoid the disturbance of birds and their nests.	Part C: § 3.11: ¶ 3.11.14-3.11.17 & 3.11.29-3.11.31	DR SpA
	72	Adopt the necessary procedures to avoid the disturbance of otters, water voles, badgers or other protected wildlife.	Part C: § 3.11: ¶ 3.11.18-3.11.21 & 3.11.29-3.11.31	DR SpA
Arrival on Site	73	Upon arrival on site, confirm the identity of the structure (ensure that it is the correct one).	Part C: § 4.1: ¶ 4.1.1	ⓘ DR
	74	Be aware that the appearance of some structural materials may sometimes be misleading.	Part C: § 4.1: ¶ 4.1.2	ⓘ DR
	75	Be aware that some structures may have been subjected to repairs or alterations which are superficially similar to the rest of the structure but which may conceal a different form of construction.	Part C: § 4.1: ¶ 4.1.2	ⓘ DR
	76	Ensure that all PPE is fitted securely and correctly.	Part C: § 3.6: ¶ 3.6.30	EoC

	ID	Guidance	Volume 1	Action
Arrival on Site	77	The team leader should make all members of the inspection team aware of the particular risks associated with the inspection, through a site-specific briefing.	Part A: § 4.2: ¶ 4.2. 3	ⓘ
Before Commencing Work	78	Do not commence or continue to work unless it is safe to do so.	Part C: § 3.3: ¶ 3.3.19 & 3.3.29 & Part C: § 3.5: ¶ 3.5.45-3.5.47	ⓘ
	79	Do not work while under the influence of alcohol or drugs or when tired or in ill health.	Part C: § 3.3: ¶ 3.3.11-3.3.12	ⓘ
	80	Avoid handling or disturbing rubbish but if it is necessary to do so, ensure that the appropriate PPE is worn.	Part C: § 3.3: ¶ 3.3.14-3.3.16	ⓘ EqR
	81	Avoid handling bird droppings at roost or nest sites unless suitable respirators and/or other PPE are worn.	Part C: § 3.3: ¶ 3.3.17 & Part C: § 3.11: ¶ 3.11.17	ⓘ EqR
	82	Be aware of 'remote areas' and follow the authority's procedures when entering such areas.	Part C: § 3.5: ¶ 3.5.20	ⓘ

	ID	Guidance	Volume 1	Action
Before Commencing Work	83	Before commencing work, ensure that necessary traffic management measures are in place and operate satisfactorily.	Part C: § 4.1: ¶ 4.1.3	EqC
	84	If scaffolds are used, they should be checked before every use for vandalism or unauthorised removal of parts and tagged (to specify the safe working load) by a suitably experienced and qualified person.	Part C: § 3.6: ¶ 3.6.13	EqC SpA
Undertaking Inspections	85	Ensure that adequate safety zones are always maintained between working and trafficked areas if working within any form of traffic management.	Part C: § 3.5: ¶ 3.5.8	ⓘ EqC
	86	At intervals during the work, undertake checks to ensure that any traffic management arrangements are still operating correctly.	Part C: § 4.1: ¶ 4.1.3	ⓘ EqC
	87	Be alert at all times and aware of surrounding hazards and, if necessary, appoint a lookout.	Part C: § 3.3 ¶ 3.3.10 & 3.3.27	ⓘ

	ID	Guidance	Volume 1	Action
Undertaking Inspections	88	Carry out inspections in a logical and systematic manner to the full requirements of the specific inspection brief and within the constraints imposed by any safety, traffic management and access considerations.	Part C: § 4.1: ¶ 4.1.4-4.1.6	ⓘ
	89	Before starting to identify individual defects, review the overall condition of the structure and focus on identifying any structural defects and their effects.	Part C: § 4.1: ¶ 4.1.4	ⓘ
	90	Be alert to anything unusual and focus on any part of the structure that may cause particular concern.	Part C: § 4.1: ¶ 4.1.7	ⓘ
	91	Never use any type of access equipment alone.	Part C: § 3.6: ¶ 3.6.5	ⓘ
	92	If a ladder is used, never lean out from it and never carry objects in your hands while ascending or descending; carry any equipment required in a haversack or shoulder bag.	Part C: § 3.6: ¶ 3.6.10	ⓘ

	ID	Guidance	Volume 1	Action
Undertaking Inspections	93	Take into account advice and guidance on carrying out inspections of structures constructed from various materials and detailed guidance on defects that may occur.	Part C: § 4.1: ¶ 4.1.1-4.1.10, Part C: § 4.2-4.11 & Part D	ⓘ
	94	If a testing programme is being implemented, review and assess its suitability as the testing is being undertaken.	Part E: § 2.2, ¶ 2.2.9	SEA SpA
Record Inspection Findings	95	Record the observed defects along with their associated severity and extent levels on an inspection pro-forma, as specified by the authority.	Part C: § 5.2: ¶ 5.2.1-5.2.4 & Part C: § 5.3: ¶ 5.3.1	DP
	96	Inform the Supervising Engineer, immediately if a defect would compromise the integrity of the structure and the safety of the public.	Part C: § 5.3: ¶ 5.3.2-5.3.6	ⓘ

	ID	Guidance	Volume 1	Action
Before Leaving the Site	97	On completing an inspection, verify that all the information required has been captured.	Part C: § 4.1: ¶ 4.1.9	DR
	98	Clear the site thoroughly of all inspection equipment and materials.	Part C: § 4.1: ¶ 4.1.9	ⓘ
	99	If working on a highway, ensure that the area is safe for public use before the highway is reopened to traffic.	Part C: § 4.1: ¶ 4.1.9	ⓘ
	100	On railways, follow a formal checking and reporting procedure to ensure safety at the end of a possession.	Part C: § 4.1: ¶ 4.1.9	ⓘ DR
Back in the Office	101	Sign and date inspection forms in paper format, as evidence in case of future potential claims by the public.	Part C: § 5.2: ¶ 5.2.5	DP
	102	Produce an inspection report in a format appropriate to the inspection type.	Part C: § 5.4	DP
	103	The Supervising Engineer should periodically review and sign inspection reports and also identify maintenance needs.	Part C: § 5.2: ¶ 5.2.5	DR

	ID	Guidance	Volume 1	Action
Back in the Office	104	Store the information obtained from all inspections in an appropriate format, for example, a computerised database.	Part C: § 5.5	DS
	105	If the inspection was the first on a structure, use the data collected to create a structure specific pro-forma for future use.	Part C: § 5.2: ¶ 5.2.4	DP
	106	Evaluate the inspection findings.	Part C: § 5.6	DR

Part B
Defect Photographs

This Part provides a library of photographs illustrating the different types of defects that are likely to be encountered in highway structures, structural components and structural materials. It also covers the definition of "severity" and provides descriptions of the general severity ratings used.

1 Introduction

1.1 GENERAL

1.1.1 This Part of the Manual contains a selection of photographs illustrating different types of defects that are likely to be encountered in highway structures. The condition of the structural or bridge elements illustrated in the photographs is presented in terms of the severity of the damage or defect.

1.1.2 Severity is the degree to which the defect/damage affects the function of one element or a number of elements on the structure. This definition has been adopted from the CSS Guidance documents on bridge inspection reporting [1, 2]. Inspectors should check with the authority the form of the reporting system to be adopted, as several have been developed and are utilised by particular owners (see also Volume 1: Part C: Section 5).

1.1.3 All defects illustrated in this Part of the Manual are assigned a severity rating which generally corresponds to one of the following ratings:

1. As new condition or defect has no significant effect on the element (visually or functionally).
2. Early signs of deterioration, minor defect/ damage, no reduction in functionality of element.
3. Moderate defect/damage, some loss of functionality could be expected.
4. Severe defect/damage, significant loss of functionality and/or element is close to failure/collapse.
5. The element is non-functional/failed.

1.2 LAYOUT OF PART B

1.2.1 The layout of this part of the Manual is summarised in the table below.

Section	Summary of content of each section
1. Introduction	This section covers the definition of "severity" and provides descriptions of the general severity ratings used throughout Part B.
2. Structural and Component Defects	This section includes a selection of photographs illustrating general structural or component defects irrespective of the structural material.
3. Concrete Defects	This section includes a selection of photographs illustrating different types of defects that are likely to be encountered on concrete elements.
4. Steel Defects	This section includes a selection of photographs illustrating different types of defects that are likely to be encountered on steel elements.
5. Masonry Defects	This section includes a selection of photographs illustrating different types of defects that are likely to be encountered on masonry elements.
6. Defects in Other Materials	This section includes a selection of photographs illustrating different types of defects that are likely to be encountered on elements made from miscellaneous materials such as cast iron, wrought iron, timber, etc.

2 Structural & Component Defects

2.1 SCOUR

a. Severity: 2 – Minor scour adjacent to wing wall

b. Severity: 2 – Minor scour at abutment wall

c. Severity: 3 – Scour around base of pier

d. Severity: 3 – Flood debris at bridge piers. This could lead to scour and overstress if not cleared.

e. Severity: 5 – Severe scour to masonry arch, causing loss of voussoirs at arch springing

2.2 SUBSTRUCTURE ROTATION/TILTING

a. Severity: 2 – Slight rotation in wingwall

b. Severity: 3 – Significant rotation of abutment wall

c. Severity: 4 – Rotation and settlement of wingwall

2.3 SETTLEMENT

a. Severity: 2 – Vertical cracks suggest differential settlement

b. Severity: 3 – Dip in the carriageway due to settlement underneath the abutment

c. Severity: 3 – Evidence of differential settlement (rotation of left-hand panel).

d. Severity: 4 – Differential settlement of reinforced earth wall

2.4 CORRODED BEARINGS

a. Severity: 2 – Minor corrosion on edges of bearing plates

b. Severity: 3 – Extensive corrosion on bearing

c. Severity: 4 – Severe corrosion to bearing

2.5 BEARINGS CLOSE TO END OF TRAVEL

a. Severity: 3 – Sliding bearing is at extreme end of travel at average temperature

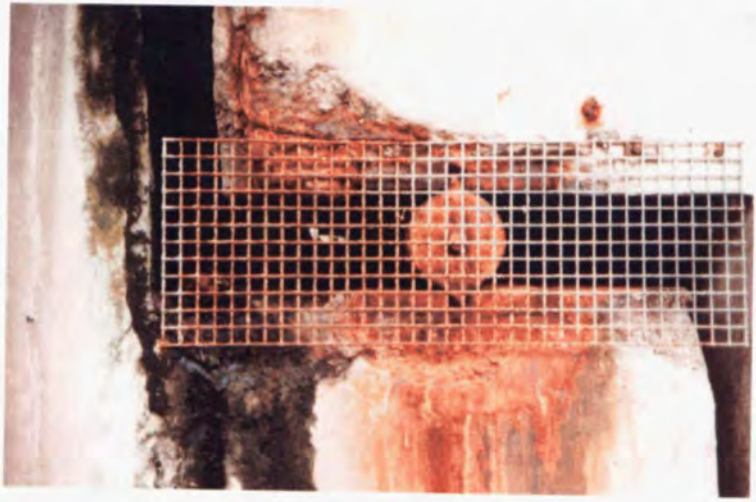
b. Severity: 4 – Bearing is beyond the designed extent of travel at average temperature

2.6 BEARINGS: SEATING DEFECTS

a. Severity: 2 – Minor localised spalls and rust staining on bearing shelf

b. Severity: 3 – Extensive delamination on bearing shelf

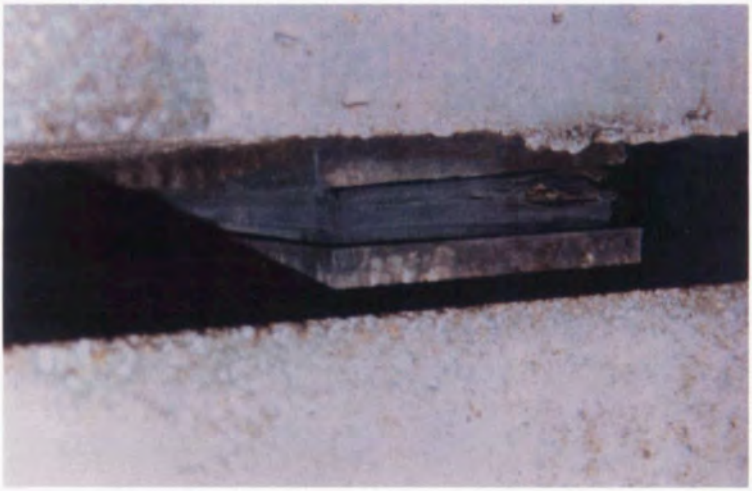
c. Severity: 3 – Extensive rust staining and spalling on bearing shelf



2.7 ELASTOMERIC BEARINGS: SPLITTING DEFECTS

a. Severity: 2 – Minor split in elastomeric bearing

b. Severity: 3 – Splitting and deformation of elastomeric bearing



2.8 BURIED EXPANSION JOINTS

a. Severity: 2 – Minor surface cracking over buried joint

b. Severity: 4 – Severe surface cracking over buried joint

2.9 ASPHALTIC PLUG JOINTS: CRACKS

a. Severity: 3 – Crack in asphaltic plug joint

2.10 ASPHALTIC PLUG JOINTS: DEBONDING

a. Severity: 2 – Debonded asphaltic plug joint

2.11 ASPHALTIC PLUG JOINTS: MATERIAL LOSS

a. Severity: 2 – Slight loss of binder and aggregate

b. Severity: 2 – Slight rutting at asphaltic plug joint with some flow of binder

c. Severity: 3 – Loss of aggregate

d. Severity: 4 – Loss of material from joint

2.12 ASPHALTIC PLUG JOINTS: TRACKING

a. Severity: 2 – Slight tracking with significant flow of binder

b. Severity: 3 – Severe tracking

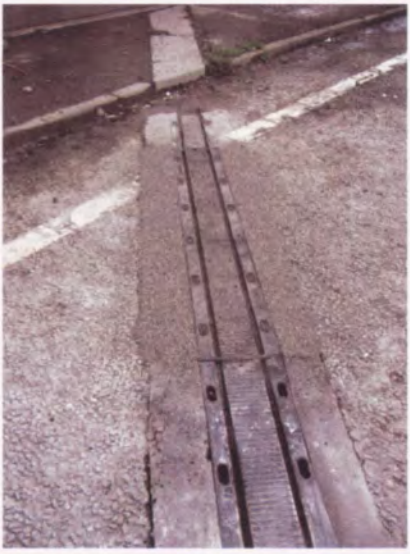
2.13 EXPANSION JOINTS: NOSING DEFECTS

a. Severity: 3 – Significant cracking

b. Severity: 4 – Failed mortar nosing repair to plate joint

2.14 ELASTOMERIC EXPANSION JOINTS

a. Severity: 2 – Slight cracking of transition strips



b. Severity: 2 – Missing holding down bolts

c. Severity: 3 – Transition strips breaking up

d. Severity: 3 – Missing holding down bolts and transition strip

e. Severity: 4 – Cracking of transition strip with significant damage to elastomeric joint

f. Severity: 5 – Loss of transition strip and metal runners, with distortion to joint rubber

2.15 FRAGMENTED SURFACING ADJACENT TO EXPANSION JOINTS

a. Severity: 3 – Moderate break up of road surfacing adjacent to joint with debris in joint seal

b. Severity: 4 – Severe break up of road surfacing adjacent to joint with debris in joint seal

2.16 HALF JOINTS

a. Severity: 2 – Minor rust staining at a half joint

Note: The above image illustrates a typical half-joint with rust staining due to leaking. In instances such as this, a severity rating is assigned based on what is visible on site. However, further examination is recommended prior to assigning a definitive severity code due to uncertainty surrounding the general condition and potential rate of deterioration of these type of joints.

2.17 PARAPETS AND SAFETY FENCES: IMPACT DAMAGE

a. Severity: 2 – Minor impact damage

b. Severity: 2 – Moderate damage to parapet infill

c. Severity: 3 – Displacement of coping at end of parapet wall due to impact, and damage to adjacent field wall

d. Severity: 4 – Impact to centre section of parapet resulting in tilting of section

e. Severity: 5 – Broken post at end of parapet

f. Severity: 5 – Impact has caused demolition of a length of parapet wall

2.18 PARAPETS AND SAFETY FENCES: CORROSION

a. Severity: 2 – Slightly corroded parapet holding down bolt on underside of deck

b. Severity: 2 – Corrosion of parapet

c. Severity: 3 – Severe corrosion on base of post with slight corrosion of holding down bolts

d. Severity: 5 – Severe corrosion at base of post; the parapet has virtually no strength

2.19 PARAPETS: CORRODED OR CRACKED WELDS

a. Severity: 3 – Significant corrosion at welds

2.20 DRAINAGE

a. Severity: 2 – Leaking drainage causing minor staining

b. Severity: 2 – Leaking drainage causing minor staining

c. Severity: 3 – Leaking drainage causing minor structural damage

d. Severity: 3 – Leaking drainage causing minor structural damage

3 Concrete Defects

3.1 PLASTIC SHRINKAGE CRACKS

a. Severity: 4 – Plastic shrinkage cracks in new bridge deck

b. Severity: 4 – Core extracted from the above bridge deck

3.2 DRYING SHRINKAGE CRACKS

a. Severity: 2 – Drying shrinkage cracks

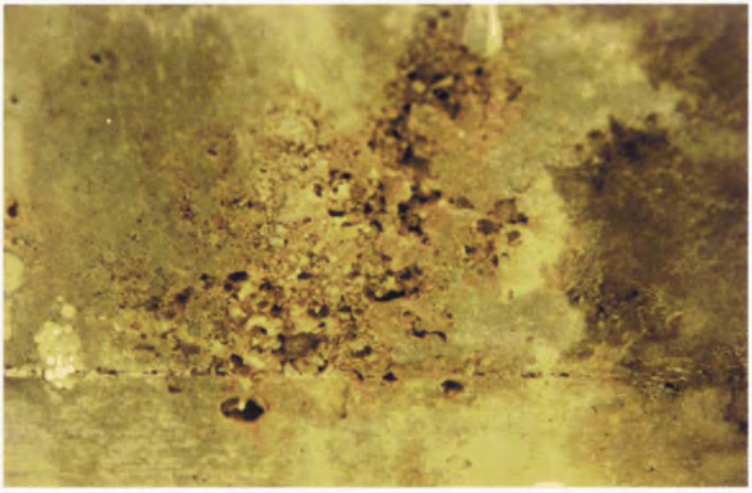
b. Severity: 3 – Drying shrinkage cracks

3.3 CRAZING

a. Severity: 2 – Pronounced crazing on soffit of deck slab

3.4 POOR COMPACTION: HONEYCOMBING

a. Severity: 2 – Poor compaction beneath void former (note polystyrene)



b. Severity: 3 – Poor compaction leading to significant honeycombing

3.5 REINFORCEMENT CORROSION CRACKING: CHLORIDES

a. Severity: 3 – No evidence of corrosion on surface, but subsequent testing revealed high chloride concentrations

b. Severity: 4 – Severe cracking and delamination in the top of a pier below a leaking expansion joint

3.6 MAP CRACKING AND ALKALI SILICA REACTION

a. Severity: 2 – Map cracking on top surface

b. Severity: 3 – Aggregate alkali reaction cracking in wingwall with brown staining typical of such crack patterns

c. Severity: 4 – Severe ASR cracking with brown staining in the cracks

3.7 INCIPIENT SPALL

a. Severity: 3 – Incipient spall in deck soffit

3.8 SPALLING

a. Severity: 2 – Minor area of spalling with exposed bars to base of pier

b. Severity: 2 – Minor areas of spalling at base of abutment wall

c. Severity: 3 – Severe spalling at deck soffit

3.9 SCALING (DUE TO FROST DAMAGE)

a. Severity: 2 – Slight scaling of surface on a wingwall

b. Severity: 3 – Significant scaling at plinth of pedestrian parapet

3.10 EFFLORESCENCE

a. Severity: 2 – Efflorescence at construction joints

b. Severity: 3 – Leaching of calcium salts at abutment joint

c. Severity: 4 – Severe leaching through deck

3.11 RUST STAINING

a. Severity: 1 – Iron pyrites stains throughout bridge, which is not an indication of corrosion

b. Severity: 1 – Corrosion of reinforcement during construction had led to staining of the soffit formwork adjacent to a construction joint

c. Severity: 2 – Rusty tie wire and debris in soffit of deck slab

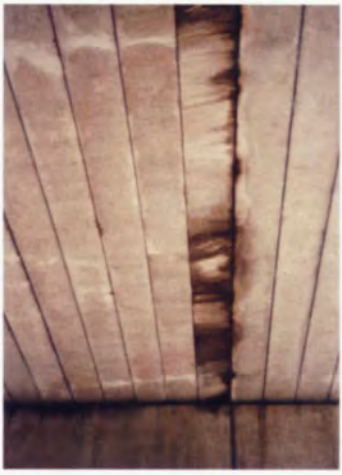
d. Severity: 3 – Significant rust staining

e. Severity: 3 – Significant leaking and rust staining through wingwall

f. Severity: 4 – Heavy leaching and rust staining from expansion joints

3.12 LEAKAGE THROUGH DECK

a. Severity: 3 – Significant leakage through inverted T-Beam deck on centreline of road



b. Severity: 4 – Heavy leakage through deck at beam/ slab joint

3.13 THAUMASITE SULPHATE ATTACK

a. Severity: 3 – TSA in the form of discrete blistering and large bands of attack on a bridge abutments

b. Severity: 4 – Extreme example of TSA in a bridge column in wet, reworked lower lias clay

3.14 SHUTTERING LEFT IN PLACE

a. Severity: 3 – Parts of shuttering left in place after removal

b. Severity: 3 – Wooden sections left in place. These could inhibit movement of the superstructure

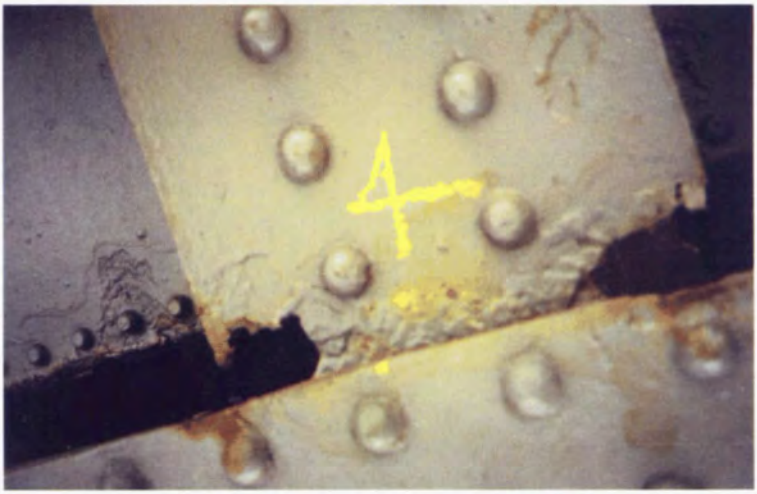
4 Steel Defects

4.1 LOSS OF SECTION DUE TO CORROSION

a. Severity: 2 – Slight to moderate corrosion of steel members

b. Severity: 3 – General corrosion over length of flange

c. Severity: 5 – Severe corrosion of flange



4.2 CORROSION OF WELDED CONNECTIONS

a. Severity: 2 – Slight corrosion of weld run

4.3 CORROSION OF BOLTED OR RIVETED CONNECTIONS

a. Severity: 2 – Slight corrosion of nuts and washers

b. Severity: 4 – Loss of rivet heads due to corrosion

4.4 DEFORMATION OF PLATES DUE TO CORROSION

a. Severity: 3 – Significant deformation

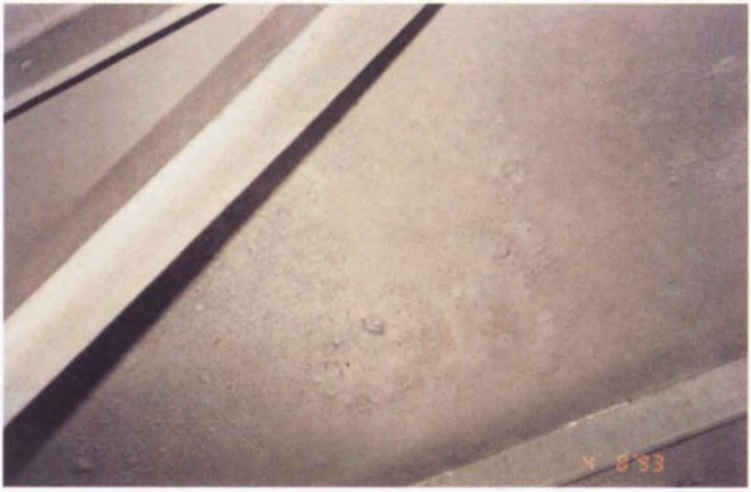
4.5 PAINT: BLISTERING

a. Severity: 2 – Slight blistering

b. Severity: 3 – Moderate blistering

4.6 PAINT: FLAKING

a. Severity: 2 – Flaking to deck plate



b. Severity: 2 – Flaking paintwork

c. Severity: 3 – Flaking and missing paint on main beam

d. Severity: 4 – Breakdown of paint on footbridge beam, allowing extensive corrosion

4.7 FIRE DAMAGE

a. Severity: 3 – Significant fire damage to paint system

5 Masonry Defects

5.1 WATER PERCOLATION

a. Severity: 3 – Severe staining and efflorescence in arch barrel

b. Severity: 4 – Severe percolation with stalactites formed

5.2 EROSION

a. Severity: 2 – Slight wind erosion

b. Severity: 3 – Significant loss of surface to parapet stones caused by rain action

5.3 FREEZE/THAW DAMAGE

a. Severity: 2 – Minor loss of surface to a pier

b. Severity: 3 – Significant loss of surface within arch barrel

c. Severity: 4 – Severe loss of face at base of parapet

5.4 MISSING MASONRY

a. Severity: 3 – Moderate loss of bricks

b. Severity: 4 – Severe loss of bricks

c. Severity: 5 – Failure due to missing bricks

5.5 CRACKS THROUGH MORTAR

a. Severity: 4 – Crack along line of joint; poor bond construction

5.6 CRACKS THROUGH MASONRY

a. Severity: 3 – Crack in centre of stone abutment

5.7 CORROSION OF EMBEDDED METALWORK

a. Severity: 2 – Spalling of brickwork in jack arch due to corrosion of metalwork

5.8 MORTAR LOSS

a. Severity: 2 – Loss of mortar from surface of joints in spandrel wall

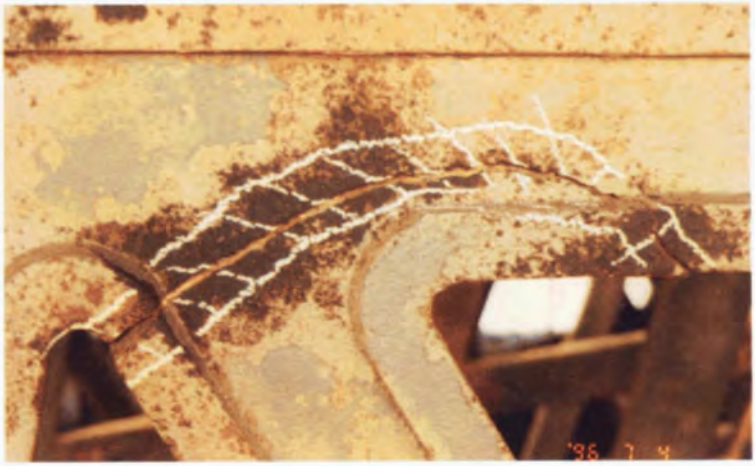
b. Severity: 4 – Extensive mortar loss

6 Miscellaneous Materials Defects

6.1 CAST IRON: CRACKING AND FRACTURE

a. Severity: 3 – Crack through abutment wall plate

b. Severity: 4 – Crack through cast iron frame



6.2 CAST IRON: BLOWHOLES

a. Severity: 3 – Blow hole in cast iron member

6.3 CAST IRON: CORROSION

a. Severity: 3 – Moderate corrosion on arch rib

b. Severity: 5 – Rust on shank of bolt causing failure of cast iron lug

6.4 WROUGHT IRON: CORROSION

a. Severity: 2 – Minor corrosion

b. Severity: 3 – Significant corrosion to flange and web of wrought iron beam

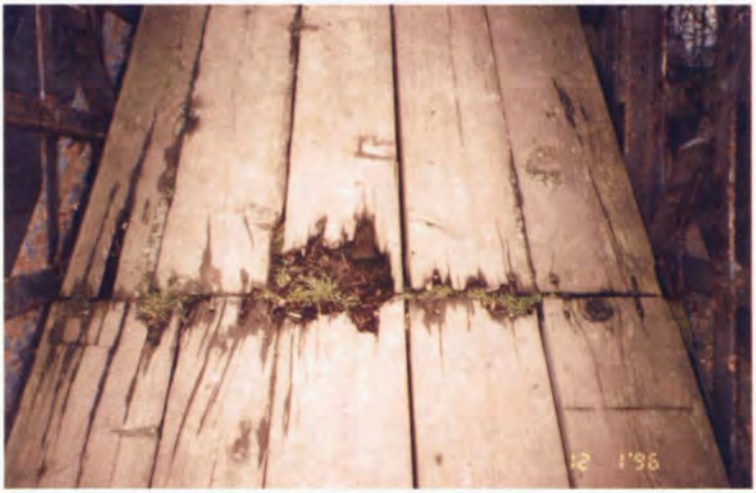
c. Severity: 5 – Perforation of web stiffener

6.5 WROUGHT IRON: DELAMINATION

a. Severity: 3 – Delamination of wrought iron section

6.6 TIMBER

a. Severity: 4 – Ends of walkway boards rotting



b. Severity: 5 – Complete local decay of timber retaining wall

7 References for Part B

1. *Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting*, County Surveyors Society, 2002.

2. *Addendum to CSS Bridge Condition Indicators Volume 2*, County Surveyors Society, 2004.

Acknowledgements

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Disclaimer

Inspection is a fundamental part of the management of highway structures. This Manual, comprising of two complementary Volumes, provides guidance on planning, preparing for and undertaking inspections of highway structures. Using this Manual will assist organisations to appreciate the wide range of issues involved in the inspection process, and enable them to set up practices which deliver safe, compliant, consistent and high quality inspections. Organisations should also consider using this Manual as a basis for inspector training.

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