# Part C
# The Inspection Process

*This Part outlines the fundamentals of the inspection process; providing guidance on scheduling and adequately planning inspections. It also lists the factors that should be considered when preparing for inspections, including consideration of environmental impacts, preparation of risk assessments and selection of the appropriate access equipment and safe methods of working. Special considerations and other details relating to performing inspections on structures constructed of different materials and certain special structures are contained in this Part. A generic process to facilitate recording, rating and reporting defects and inspection results is presented.*

# Section 1 Introduction

## 1.1 OVERVIEW

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 approach is required for the development and delivery of a robust inspection regime. This Part of the Manual presents a rational five step process for developing an inspection regime and this is shown in Figure C.1. It is recommended that owners of highway structures adopt this process.

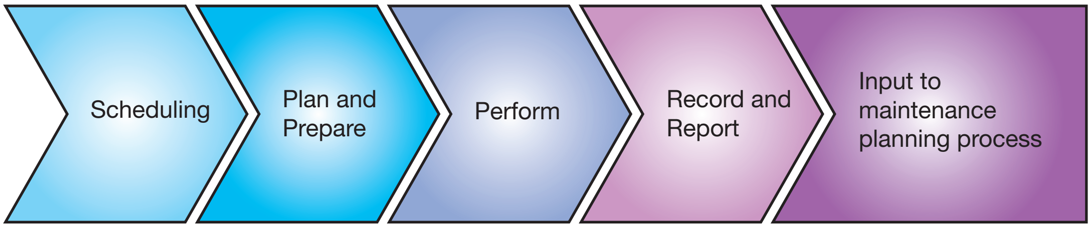


**Figure C.1 – The inspection process**

1.1.2 An outline of the above inspection process is provided in Table C.1. The layout of this Part of the Manual aligns with this process; with each section providing details on a specific part of the process. The topics covered herein apply to all inspection types, however, the amount of time and effort required should be commensurate with the specific circumstances and inspection type.

**Table C.1 – Layout of Part C**

| Section | Summary of purpose and content of each section |
|---|---|
| 2. Scheduling Inspections | This section provides guidance on scheduling inspections and outlines the factors that should be considered when programming different types of inspections. |
| 3. Planning and Preparing for Inspections | This section provides guidance on adequately planning and preparing for inspections and outlines the factors that should be considered. It provides advice on the preparation of method statements and risk assessments and guidance on the selection of appropriate access and other equipment. This section also outlines Health and Safety considerations and potential environmental impacts. |
| 4. Performing Inspections | This section provides details relating to performing inspections on structures constructed of different materials and certain special structures. |
| 5. Recording Inspection Findings | This section provides recommendations on the adoption of a generic process that would facilitate the recording, rating and reporting of defects and inspection results. |
| 6. Inputs to the Maintenance Planning Process | This section provides brief guidance and appropriate references that should be utilised for the input of the inspection findings into the maintenance planning process. |

## 1.2 A PRAGMATIC APPROACH

1.2.1 It is important that the process described in this Part of the Manual is tailored to needs, i.e. the inspection type (e.g. Safety, General, Principal or Special) and the characteristics of the structure stock. There is a considerable body of information provided in this Part, covering a wide range of areas (e.g. scheduling, safety and environmental considerations). If these considerations are not dealt with in a rational and pragmatic manner then the scheduling, planning and delivering of inspections can quickly become cumbersome and resource intensive. In order to avoid this it is recommended that:

- The Supervising Engineer, or a suitably competent member of the inspection team, develops a sound overall understanding of and stays abreast of the key issues covered by this Part of the Manual, including contacts with staff/organisations that can provide more in-depth guidance on specific issues.

- The structure files/records for each structure are stored and maintained in such a manner that relevant information can be readily accessed, reviewed and where required, updated during the inspection process. This avoids lengthy repetition of data compilation during each inspection cycle. Any information that may need to be checked for relevance (i.e. criteria that are likely to change over time) should be suitably flagged in the files/records.

- The Supervising Engineer, or a suitably competent member of the inspection team, lists those factors that are relevant for the different types of inspections and for different families of structures.

1.2.2 This approach should assist authorities to develop an efficient and effective inspection process, enabling them to avoid unnecessary commitment of resources on issues that are not relevant to a particular inspection or structure type.

# Section 2
# Scheduling Inspections

## 2.1 INTRODUCTION

2.1.1 Inspections should be scheduled to make the most efficient use of the resources and to minimise disturbance to the public, e.g. scheduling inspections to take advantage of traffic management planned for other reasons. In all cases, a rational schedule that takes account of the stock characteristics should be developed.

2.1.2 When scheduling inspections, consideration should be given to the issues raised in the following sections, these are summarised in Table C.2.

**Table C.2 – Scheduling Inspections**

| No | Items to be considered | Comments | Paragraph |
|---|---|---|---|
| 1 | The type of inspection required | Safety, General, Principal, Special, Acceptance, or Inspection for Assessment, and considerations for decreasing or increasing their inspection intervals | 2.2 |
| 2 | Objectives of the inspection | Why is the inspection being carried out?<br>What information is required?<br>How does this fit in with the management of the structure? | 2.3 |
| 3 | Criteria that influence or constrain the inspection schedule | What criteria may influence the scheduled date of an inspection, e.g. resource availability, co-ordinating with other works, seeking efficiencies in the programme, environmental issues etc.? | 2.4 |

## 2.2 INSPECTION TYPES

2.2.1 A summary of the inspection types is provided in Table C.3. Further details on each inspection type are provided in the following paragraphs, this aligns with the guidance provided in the Code of Practice for the Management of Highway Structures [1] and BD 63 [2].

| Table C.3 – Summary of Inspection Types | | |
|---|---|---|
| **Inspection Type** | **Nominal Interval** | **Description** |
| Safety Inspection (or Routine Surveillance) | At frequencies which ensure timely identification of safety defects and reflect the importance of a particular route or asset. | Cursory inspection carried out from a slow moving vehicle, in certain instances staff may need to proceed on foot. |
| General Inspection | 2 years | Visual inspection from the ground level.<br>Report on the physical condition of all structural elements visible from the ground level. |
| Principal Inspection | 6 years | Close visual examination, within touching distance; utilising, as necessary, suitable inspection techniques.<br>Report on the physical condition of all inspectable structural parts. |
| Special Inspection | Programmed or when needed | Detailed investigation (including as required inspection, testing and/or monitoring) of particular areas of concern or following certain events. |
| Acceptance inspections | When needed | A formal mechanism for exchanging information prior to changeover of responsibility. |
| Inspection for Assessment | When needed | Inspection undertaken to provide information required to undertake a structural assessment. |

**Safety Inspection/Routine Surveillance**

2.2.2 The purpose of a Safety Inspection (or Routine Surveillance) is to identify obvious deficiencies which represent, or might lead to, a danger to the public and therefore require immediate or urgent attention.

2.2.3 If a Safety Inspection, or other source, reveals a possible defect requiring urgent attention, including defects that may represent a hazard to road, rail and other users, the Supervising Engineer should immediately take such action as is required to safeguard the public and/or sustain structural functionality. In such circumstances the appropriate third parties should also be notified, e.g. the police, the public, other owners.

2.2.4 Safety Inspections are not specific to highway structures and generally cover all fixed assets on the highway network, including carriageways, footways, structures, drainage, verges and lighting. Safety Inspections are normally carried out by trained highway maintenance staff from a slow moving vehicle. In certain circumstances staff may need to proceed on foot either to confirm suspected defects or to complete the inspection. For example, some bridges, such as footbridges or underpasses with high pedestrian usage, may require a weekly or monthly walkover.

2.2.5 Safety Inspections should be scheduled and undertaken at frequencies which ensure the timely identification of safety related defects and reflect the importance of a particular route or asset. Safety inspections may also be a result of a defect notification by a third party e.g. police or public.

2.2.6 As such, a Safety Inspection only provides a cursory check of those parts of a highway structure that are visible from the highway with the aim of identifying any obvious deficiencies or signs of damage and deterioration that may require urgent attention or may lead to accidents or high maintenance costs, e.g. collision damage to superstructure or bridge supports, damage to parapets, spalling concrete and insecure expansion joint plates.

**General Inspection**

2.2.7 The purpose of a General Inspection is to provide information on the physical condition of all visible elements on a highway structure.

2.2.8 A General Inspection comprises a visual inspection of all parts of the structure that can be inspected without the need for special access equipment or traffic management arrangements. This should include adjacent earthworks or waterways where relevant to the behaviour or stability of the structure. Riverbanks, for example, in the vicinity of a bridge should be examined for evidence of scour or flooding or for conditions, such as the deposition of debris or blockages to the waterway, which could lead to scour of bridge supports or flooding.

2.2.9 General Inspections should be scheduled and carried out at two year intervals following the previous General or Principal Inspection. When a General Inspection coincides with a due Principal Inspection, only the Principal Inspection should be undertaken.

**Principal Inspection**

2.2.10 The purpose of a Principal Inspection is to provide information on the physical condition of all inspectable parts of a highway structure. A Principal Inspection is more comprehensive and provides more detailed information than a General Inspection. Principal Inspections should be scheduled and carried out at six year intervals, as a replacement of a General Inspection.

2.2.11 A Principal Inspection comprises a close examination, within touching distance, of all inspectable parts of a structure. This should include adjacent earthworks and waterways where relevant to the behaviour or stability of the structure. A Principal Inspection should utilise as necessary suitable inspection techniques, access and/or traffic management works. Suitable inspection techniques that should be considered for a Principal Inspection include hammer tapping to detect loose concrete cover and paint thickness measurements. Limited testing may be undertaken during a Principal Inspection; however, this is not a requirement. When appropriate, a Principal Inspection may be combined with a Special Inspection, monitoring activities, detailed testing work or routine/planned maintenance.

**Special Inspection**

2.2.12 The purpose of a Special Inspection is to provide detailed information on a particular part, area or defect that is causing concern, or inspection of which is beyond the requirements of the General/Principal Inspection regime.

2.2.13 A Special Inspection may comprise a close visual inspection, testing and/or monitoring and may involve a one-off inspection, a series of inspections or an on-going programme of inspections. As such, Special Inspections are tailored to specific needs or special requirements.

2.2.14 Special Inspections are carried out when a need is identified. For example, based on the specific characteristics of the structure, identified by a General, Principal or Safety Inspection, to follow certain events, or to consider parts of the structure more closely or at a more frequent interval that the normal General/Principal Inspection regime. Table C.4 provides guidance on scheduling Special Inspections and a list of situations when special requirements of different types of structures or elements of structures may instigate the need for Special Inspections to be considered. A number of these inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections, as appropriate, and this is identified in Table C.4.

**Table C.4 – Scheduling Special Inspections**

| **Reason for Inspection** | **Interval** | **Recommendations** |
|---|---|---|
| Underwater parts of structures | 6 years | A programme of underwater inspections should be prepared and implemented. These inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections. |
| Structures at risk from scour | 6 years | An inspection may be required to check for changes to the geometry of the river and for general degradation of the bed. These inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections. |
| Structures at risk from scour located on steep, upland rivers with potential lateral instability | After major floods | An inspection may be required to check for changes in the river channel. Further guidance on assessing the risk of scour is provided in BA 74 [3]. |
| Settlement, tilting or other movement is observed greater than that allowed for in the design | When needed | An inspection may be required to identify the cause and assess the urgency of remedial measures, and if necessary monitor the rate of movement, by developing a programme of inspections. |
| Structures in areas of mineral extraction | When needed | An inspection may be required to ascertain the condition of the structure after subsidence occurs and determine the extent of the damage caused. |
| Structures with weight or other restrictions | 6 months | Where the interim measures require monitoring, an inspection should be carried out in accordance with BD 79 [4]. Where the interim measures consist of temporary propping or width restrictions, a visual check to ensure that these are still functioning correctly is required. |

Continued

| **Table C.4 – Scheduling Special Inspections** (continued) | | |
|---|---|---|
| **Reason for Inspection** | **Interval** | **Recommendations** |
| Structures that have to carry an abnormal heavy load | When needed | Structures that have to carry an abnormal heavy load. When needed The structure should be inspected before, during and after the passage of the load if either an assessment has indicated that the margin of safety is below that which would be provided for a design to current standards; or similar loads are not known to have been carried. |
| Structures subjected to major accident/impact, chemical spillage and/or fire | When needed | The structure should be inspected to investigate possible structural damage. A programme of inspections may be required to monitor the damage until such time as a permanent repair is carried out. The frequency of these inspections will depend on the structural importance of the member affected and the extent and severity of the damage. |
| Concrete structures at risk from reinforcement corrosion | When needed | An inspection of concrete elements at risk from reinforcement corrosion may include a combination of a visual inspection and any of the tests described in Volume 1: Part E: Section 5. BA 35 [5] provides guidance on limited site testing that may be employed as part of a Special Inspection, i.e. half-cell potential, chloride level, covermeter and depth of carbonation. The scope of this testing should be compatible with any preventative maintenance strategy for the structure. |
| Post tensioned concrete bridges | When needed | Post-tensioned concrete bridges with grouted tendon ducts are particularly vulnerable to corrosion and severe deterioration where internal grouting of the ducts is incomplete, allowing moist air, water or de-icing salt to enter the ducting. These types of bridges should be inspected in accordance with BA 50 [6]. |
| Structures strengthened by the use of externally bonded plates | 6 months for the first 2 years | Structures should be inspected to ensure that the externally bonded plates are functioning as intended, e.g. they are not detached. Inspections should be scheduled and carried out at intervals not exceeding six months for the first two years after strengthening and thereafter in accordance with the intervals prescribed in the maintenance records.<br><br>For concrete structures a manual of the inspection procedures required should be prepared in accordance with BA 30 [7]. Particular requirements for the inspection of structures strengthened with fibre composites are included in the Concrete Society Technical Report 57 [8]. |

Continued

| **Table C.4 – Scheduling Special Inspections** (continued) | | |
|---|---|---|
| **Reason for Inspection** | **Interval** | **Recommendations** |
| Steel and steel composite structures at risk from corrosion | When needed | Steel is particularly vulnerable to corrosion when exposed to certain environments. Most highway structures steelwork is protected with paint or other protective coatings. Inspections of the protective system may be required in order to identify or monitor corrosion or in order to identify the extent and rate of deterioration. |
| Weathering steel structures | Various | Special Inspections should be scheduled and carried out throughout the life of these type of structure in accordance with BD 7 [9], i.e. immediately after construction; every 2 years (visual examination of critical areas to investigate patina irregularities); and every 6 years (to check thickness measurements). These inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections. |
| Cast iron structures | 6 months | Cast iron members on structures should be inspected at intervals not exceeding six months to identify any cracked or fractured elements and to determine the cause and extent of deterioration. Monitoring of changes in the cracking may be required; this may be achieved through a programme of follow-on inspections and/or appropriate crack monitoring techniques (see Volume 1: Part E: Section 4). |
| Bearings. | 6 years or as agreed with the authority | Inspections of bearings should be carried out in accordance with BS EN 1337-10 [10]. For bearings types other than those described in BS EN 1337-10 [10], engineering judgement should be used to determine the inspections required. These inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections. |
| Hangers in structures with suspended spans | 6 years | Hangers are usually critical elements whose failure would be catastrophic. The nature of the inspection, apart from a close visual inspection of all surfaces at touching distance, will depend on the form and materials of construction. Detailed requirements should be agreed with the authority. These inspections may be scheduled to coincide and be undertaken in conjunction with Principal Inspections. |
| Pre-contract surveys | When needed | When maintenance work is planned, an inspection including relevant tests and measurement will usually be necessary to ascertain the nature and extent of work required. |

Continued

| **Table C.4 – Scheduling Special Inspections** (continued) | | |
|---|---|---|
| **Reason for Inspection** | **Interval** | **Recommendations** |
| Geometric data | When needed to supplement structure records | Detailed geometric measurements may be required when as-built or construction drawings do not exist for a structure; or when specific dimensions are subject to doubt. Critical dimensions such as headroom or lateral clearances may need to be checked after maintenance work or modifications are carried out on a structure or adjacent highway. If a detailed check of headroom is required, the procedure set out in Annex A of BD 65 [11] should be followed. Inspections undertaken to ascertain such measurements, may be scheduled to coincide with a Principal Inspection. |
| Permanent access gantries | Prior to use and at regular intervals | Permanent access gantries (also see paragraphs 3.6.25-3.6.27) should be inspected prior to use and at regular intervals in accordance the Institution of Structural Engineers report on The Operation and Maintenance of Bridge Access Gantries and Runways [12]. |
| Hoists, winches and associated cables | At regular intervals | Hoists, winches and associated cables should be inspected in accordance with the requirements of the relevant orders under the Factories Act [13]. |
| Machinery for movable bridges | As prescribed in the maintenance records | Electrical and mechanical equipment for operating movable bridges should be inspected at regular intervals to ensure that the equipment is maintained in a safe and operable condition. A programme of inspections should be prepared for each movable bridge, setting out the specific requirements. |
| Electrical and mechanical equipment in subways, underpasses and tunnels | As prescribed in maintenance records | Electrical and mechanical equipment (e.g. lighting and ventilation) should be inspected at intervals that comply, as a minimum, with the manufacture's recommendations. In certain circumstances the Supervision Engineer may wish to set down a more onerous regime in the maintenance records, for example, weekly checks of lighting in pedestrian underpasses (Note: inspections of lighting equipment should be in agreement with the authority's lighting engineers and align with the lighting Code of Practice [14]). |

Continued

| **Table C.4 – Scheduling Special Inspections** (continued) | | |
|---|---|---|
| **Reason for Inspection** | **Interval** | **Recommendations** |
| Specific problems | When needed | Following the discovery of a specific problem, it may be necessary to arrange a single or series of inspections to confirm the cause and extent of the defects and to enable the appropriate course of action to be determined. If a specific problem is found on a structure, consideration should be given to undertaking inspections on structures of similar construction form and/or material, e.g. the discovery of concrete degradation due to thaumasite sulfate attack or alkali silica reaction. |
| Other reasons | When needed | There may be a need for Special Inspections at structures due to reasons other than those set out above. Possibilities include, but are not restricted to: structural distress; investigation of a severe defect reported at an inspection; cladding failure; bulging, sliding or tilting of spandrel walls; unexplained cracking; condition of vulnerable details such as half or hinge joints; and water leakage. Except in cases of emergency, the need for the inspection should be agreed with the Supervising Engineer. |

**Acceptance inspections**

2.2.15 The need for an Acceptance Inspection should be considered when there is a change over of responsibility from one party or highway authority to another, for the operation, maintenance and safety of a structure.

2.2.16 The purpose of an Acceptance Inspection is to provide the party taking over responsibility for the structure with a formal mechanism for documenting and agreeing the current status of, and outstanding work on, a structure prior to handover. The scope of an Acceptance Inspection depends on the circumstances, e.g. handover of a new structure, transfer of an existing structure, handback of a structure after a concession period. Acceptance responsibilities and activities depend upon the form of contract, but the Acceptance Inspection is normally carried out by the party taking over responsibility but who may be accompanied by the other party to facilitate agreement. Further details on the format, content and timing of Acceptance Inspections are included in BD 63 [2].

**Inspection for Assessment**

2.2.17 The purpose of an Inspection for Assessment is to provide information required to undertake a structural assessment. Such inspections are necessary to verify the form of construction, the dimensions of the structure and the nature and condition of the structural components. The inspection should cover not only the condition of individual components but also the condition of the structure as an entity, especially noting any signs of distress and its cause.

2.2.18 The inspection should be sufficient to enable the dead and superimposed dead loads on the structure, and the disposition of live loading, to be determined; or to enable the strengths of members to be calculated, including allowance for deficiencies, and to confirm the dimensions and articulation for any structural model.

2.2.19 Samples are often needed to determine material strengths. Where dimensional checks are required in order to determine or confirm the structural details, such checks may require exploratory excavations, probing or boring to determine depth and extent of foundations or extents of internal features. The amount of investigation required will depend on the availability and reliability of the structure records. Site testing may also be required when an Inspection for Assessment is undertaken, in such cases careful planning of these activities is essential. BD 21 [15] provides guidance and outlines the factors that should be considerations prior to undertaking an Inspection for Assessment.

**Increasing or Decreasing the Inspection Interval**

2.2.20 Formal guidance on increasing or decreasing the aforementioned inspection intervals is provided in the Code of Practice [1] and BD 63 [2]. Particular regard should be given to the need for a formal risk assessment when increasing the interval between Principal Inspections.

## 2.3 OBJECTIVES OF THE INSPECTION

2.3.1 Inspections are an integral part of the maintenance and management of highway structures and are carried out for a variety of reasons. It is important for the Supervising Engineer and the inspector to have a clear understanding of the objectives of the inspection and how the work fits into the management plan for the structure.

2.3.2 All structural maintenance and management activities have the ultimate aim of ensuring the continued safety and functionality of the structure. However, the work may be subdivided into three phases, each with different objectives:

- ***Phase 1: Condition Monitoring*** – the process of inspecting, testing and recording the condition of the structure;
- ***Phase 2: Diagnosis*** – the process of deciding the causes of any defects which are observed;
- ***Phase 3: Solution Development*** – the process of determining what remedial measures may be required to address the detected faults, defining the scopes of work and carrying out maintenance.

2.3.3 Inspections may be required during each phase. Most inspections fall clearly into Phase 1, e.g. Safety, General and Principal Inspections, others may have objectives that cover two phases, e.g. Special Inspections fall into Phases 1 and 2.

## 2.4 CRITERIA THAT INFLUENCE THE INSPECTION SCHEDULING

2.4.1 There are a wide range of criteria that can potentially influence the date of an inspection. Some of the more common issues that should be taken into account during the scheduling of inspections include:

- Inspection requirements
- Efficient use of resources

- Availability of resources
- Traffic management
- Structures near or on railways or watercourses
- Weather conditions
- Tidal locations
- Environmental issues
- Coordination of works
- Scheduling tolerances

2.4.2 The following sections provide guidance on each of the above. It is important that this is used in conjunction with any structure specific or local criteria that may influence the inspection date.

**Inspection requirements**

2.4.3 The inspection schedule should align with nationally recognised inspection frequencies (see Table C.3 and Table C.4). Where authorities deviate from these recognised frequencies it is important that they fully document their reasons for the departure and the supporting rationale for the alternative timings (this is particularly the case for longer intervals between General and Principal Inspections). Careful consideration should be given to increased inspection intervals as this could lead to defects becoming more severe before they are detected, possible danger to the public and may leave the authority exposed to liability claims.

**Efficient use of resources**

2.4.4 The inspection schedule should seek to make efficient use of resources. For example, a significant factor in inspections is the time taken to travel to and from the structure. As such it may be prudent and efficient to aim to undertake inspections along particular routes or in the same area at the same time, thereby minimising the time wasted in travelling.

2.4.5 Authorities should also consider the most efficient arrangement for inspecting structures, e.g. in-house inspectors or consultants/contractors. This will depend on arrangements in place (e.g. term maintenance contact) and the characteristics of the structure stock. However, it is fundamental that the quality of the inspection staff is not comprised by drives for efficiency savings.

**Availability of resources**

2.4.6 The inspection schedule must be commensurate with the availability of resources, primarily inspection staff, i.e. there is little point in preparing an inspection schedule if the internal/external staff are not available at the specified times. Issues to consider are:

- The size of the structure stock to the number of inspectors.

- The average time required for different inspection types, e.g. General and Principal Inspections.

- The average number of inspectors that need to be present for different inspection types, e.g. General and Principal Inspections. This should include consideration of any shadowing/training needs for new/existing inspectors.

- Other commitments of in-house inspection staff, for example, are they also responsible for building, depot, carriageway etc. inspections and/or other duties, and what constraints do these have on their availability.

- Other commitments of external/term maintenance contractors/consultants, for example, are they committed to undertake inspections for several clients.

2.4.7 Consideration should also be given to the availability of inspection equipment, be this internal (e.g. ladders, data logging devices, pool vehicles) and external equipment (e.g. mobile platforms).

**Traffic Management**

2.4.8 The inspection programme may be constrained by traffic management requirements, for example, on busy roads there may be only be limited periods when lane closures are permitted. In some cases, inspections may need to be carried out at night; however, it must be remembered that night work is inherently more dangerous and has its own environmental impacts which should be taken into consideration (see paragraphs 3.11.1-3.10.6 and 3.5.55-3.5.61).

**Structures near or on railways or watercourses**

2.4.9 Inspections near or on railways or watercourses should be arranged with, and carried out in full accordance with the requirements of, the relevant body. Severe restrictions usually apply to the timing of work affecting railways. Track possessions and electrical isolations are often only available overnight or on Sundays and generally need to be arranged well in advance. Similarly, access to bridges over canals can be seriously restricted by navigation requirements during the busier period of the year, from March to October.

**Weather Conditions**

2.4.10 When programming inspections, due regard should be given to prevailing weather conditions, for example it may be preferable to inspect the majority of structures on a specific route during the summer when there is longer daylight and more clement weather. However, the practice of inspecting structures during the summer and then writing up reports in the winter should not be adopted. The inspection reports should be prepared and submitted soon after the inspection, without exceeding the maximum durations specified by the authority.

2.4.11 Some defects, such as leaking joints, blocked drainage or cracks in concrete elements, are more prominent during or just after rainfall. While it is difficult to programme work to coincide with wet weather, the opportunity should not be overlooked. For example, bridges inspected during dry weather could be revisited (as part of a Safety Inspection) during the next spell of rain to check whether expansion joints or drainage are leaking.

**Tidal Locations**

2.4.12 For structures at tidal locations, planning inspections to coincide with tidal conditions can be advantageous. For instance, spring tides may afford access to more parts of the structure whereas neap tides may afford slower tidal flow and less change in water level.

**Environmental Issues**

2.4.13 When scheduling inspections, due consideration should be given to environmental issues which may influence the timing of inspections, such as nesting birds, hibernating bats etc. If access is required over agricultural land, the timing of the inspection could be affected by growing crops or other farming activities.

2.4.14 Particular consideration should be given to protected species of flora (e.g. fen orchid, shore dock and meadow clary) and fauna (e.g. bats, otters, water voles and great crested newts). The Supervising Engineer may be familiar with some species but expert advice may be required to identify particular environmental issues at a specific site. As well as the advice included in paragraph 3.11, details of suitable sources of environmental guidance may be obtained from the organisations listed in Appendix A.

**Coordination of Works**

2.4.15 Wherever advantageous and practicable, inspections should be co-ordinated with maintenance or other activities, forming an integral part of the maintenance strategy for the route. On busy roads it will usually be necessary to book the roadspace with the engineer responsible for co-ordinating maintenance activities on that length of road. The Supervising Engineer should liaise with other staff, owners, organisations and the public, as necessary.

2.4.16 If use can be made of equipment or traffic management required for other maintenance works, then cost efficiencies can be made and the disruption to road users reduced. At the very least, the Supervising Engineer should consult other colleagues within the authority, and/or view planned schemes on the Asset Management System, to find out what else may be planned. When inspections are carried out in conjunction with other maintenance work, care must be taken to ensure that any interference between the two activities is taken into account when preparing method statements and risk assessments (see paragraphs 3.2 and 3.4). Two safe methods of working may become dangerous if carried out close to each other or at the same time.

2.4.17 Similarly, when a transport link (e.g. road, rail or water) managed by another authority is affected the Supervising Engineer should consult with the appropriate body. They should obtain the necessary permissions with regards to any restrictions or obstructions and co-ordinate the inspection with any work that may be undertaken on the other authority's network.

**Scheduling Tolerances**

2.4.18 General and Principal Inspections should ideally be scheduled in accordance with the intervals defined in paragraph 2.2. Given the aforementioned influencing criteria, in some circumstances it may be appropriate to alter the scheduled date of an inspection in order to produce a more rational and deliverable schedule e.g. bringing forward or delaying inspections. In such circumstances it may be appropriate to vary the scheduled date by up to ± 6 months provided the Supervising Engineer is satisfied that any marginally increased inspection interval is acceptable. The timing of the following General or Principal inspection should remain as per the original schedule, and should not be changed to accommodate the altered timing of this inspection.

# Section 3
# Planning and Preparing for Inspections

## 3.1 INTRODUCTION

3.1.1 Adequate planning is fundamental to undertaking inspections safely and efficiently and ensuring that the requisite information is obtained. Appropriate planning should consider the factors described in the following sections and summarised in Table C.5.

**Table C.5 – Planning and Preparing for Inspections**

| No | Items to be considered | Comments | Paragraph |
|---|---|---|---|
| 1 | Method statement | A method statement should be prepared in conjunction with the risk assessment. | 3.2 |
| 2 | Health and Safety | The appropriate health and safety considerations should be taken into account e.g. review the structure H&S file, check if CDM regulations apply, consider personal and public safety. | 3.3 |
| 3 | Risk assessment | A risk assessment including mitigation measures for dealing with hazards should be undertaken before work starts. | 3.4 |
| 4 | Methods of access | How will access be gained to the required part(s) of the structure? | 3.5 |
| 5 | Equipment needed | The equipment required for the inspection needs to be determined and its availability and serviceability checked. | 3.6 |
| 6 | Structure records | What records are available? e.g. drawings, previous inspection reports, etc. | 3.7 |
| 7 | Type and extent of testing | Types of tests, their location, extent and intensity. | 3.8, Part E |
| 8 | Competence of inspection staff | Inspectors of the appropriate calibre for the work are essential. | 3.9, Part A: 4.2 |
| 9 | Notification of the work | There may be a need to notify other parties and, in some cases, to obtain their approval of the proposed inspection. | 3.10 |
| 10 | Environmental impacts | Is the scope and nature of work likely to affect the public or nearby sensitive wildlife habitats? | 3.11 |

## 3.2 METHOD STATEMENT

3.2.1 As part of the planning process a method statement that summarises all relevant information should be prepared and agreed before undertaking an inspection. The method statement should take into account access requirements, environmental considerations and Health and Safety checks. The method statement should be developed in parallel with the risk assessment (see paragraph 3.4), for identifying and assessing potential risks and formulating and refining the safest method of working. If the work falls within the scope of the *Construction (Design and Management) Regulations* [16], the appropriate procedures must be followed and a Health and Safety file prepared or updated. The content and level of detail should be commensurate with the circumstances and the type of inspection. However, the following information should normally be included in the method statement:

- Details and programme of the work to be undertaken during the inspection.
- Equipment required.
- Methods of access to be used.
- Traffic management details.
- A risk assessment including safe procedures for dealing with hazards.
- Resources and competence of staff that will carry out the inspection.
- Planned working times.
- Temporary works to be provided.
- Protection from highway, railway or other traffic.
- Requirements for action by others.
- Any co-ordination or notification required.
- Any environmental impacts of the work.

3.2.2 Copies of the method statement and risk assessment should be retained for future reference. In many cases it will be appropriate for these to be added to the structure Health and Safety File, which is required for any work within the scope of the CDM Regulations. Generic method statements and risk assessments may be appropriate for groups of similar structures.

3.2.3 The inspection team should familiarise themselves with the method statement and risk assessment (see paragraph 3.4) to ensure that they are aware of what is required, how work is going to be conducted, what their respective roles are and how identified risks would be mitigated.

## 3.3 HEALTH AND SAFETY

3.3.1 Inspections of highway structures, including any testing should be managed to comply with the requirements of the *Health and Safety at Work Act* [17], the *Management of Health and Safety at Work Regulations* [18], the *Construction (Health, Safety and Welfare) Regulations* [19] and any associated regulations contained in the *Approved Codes of Practice* [20, 21, 22] and in the *Construction Health and Safety Manual* [23]. In addition to these requirements, inspection personnel should comply with the authority's internal health and safety procedures when planning and undertaking inspections of highway structures. These often include guidelines and check lists for staff working in a variety of situations. An example of a check list for personal safety of staff is provided in Appendix B.

3.3.2 The *Health and Safety at Work Act* [17] provides a comprehensive framework to minimise risks to people arising from workplace activities, including the public and others who may be affected by the work activities, as well as those actually carrying out the work. A Supervising Engineer would be defined as an employer, under the *Act* [17], of organisations they instruct to carry out work on their behalf as well as members of their own staff. They have a basic duty of care to act, as far as is reasonably practicable, to minimise health and safety risks to organisations they employ and the employees of those organisations. Fulfilment of the duty may involve monitoring or provision of:

- safe plant and systems of work;
- safe use, handling, storage and transport of articles and substances;
- necessary information, instruction, training and supervision;
- a safe place of work and the means of access to and egress from that place;
- a working environment which is safe and healthy and which includes adequate welfare facilities.

3.3.3 Health and Safety requirements that should be given particular regard in relation to the inspection of highway structures include, but are not restricted to:

- Presence of asbestos (see paragraphs 3.3.7-3.3.8);
- Personal Safety (see paragraphs 3.3.9-3.3.25);
- Public Safety (see paragraphs 3.3.26-3.3.29);

3.3.4 Health and Safety requirements that should be given particular consideration in regard the methods of access that may be employed during inspections are described in detail in Section 3.5 and include, but are not restricted to:

- Working on or adjacent to live highways (see paragraphs 3.5.4-3.5.20);
- Working on or over railways (see paragraphs 3.5.21-3.5.22)
- Working in or over water (see paragraphs 3.5.23-3.5.29);
- Working underwater (see paragraphs 3.5.31-3.5.41);
- Working in confined spaces (see paragraphs 3.5.42-3.5.54)
- Night time working (see paragraphs 3.5.55-3.5.61);
- Encountering toxic mould (see paragraph 3.5.47);

- Working at height to access elements of structures to be inspected, using scaffold, mobile elevating work platforms, etc. (see paragraphs 3.6.9-3.6.27);

3.3.5 The *Construction (Design and Management) Regulations* [16, 20, 24, 25] place specific duties on those involved in construction work, which includes investigations (but not site survey), maintenance and repair as well as new construction. These duties relate to the ways that health and safety aspects are managed during the design, planning and construction phases. Some inspections fall within the scope of these Regulations, especially Special Inspections and Inspections for Assessment, which involve extensive investigation and testing. However, it is unlikely that Acceptance, Safety, General, or Principal Inspections will do so.

3.3.6 As part of the preparation for an inspection, it will be necessary for the Supervising Engineer to ascertain whether the work will be within the scope of the *CDM Regulations* and if so, the required procedures should be complied with [16, 20, 24, 25]. These will include the preparation of a Health and Safety File, which should be retained for future reference.

**Presence of Asbestos**

3.3.7 Asbestos in bridges is commonly found within the waterproofing system, as permanent formwork, in drainage pipework or as insulation to water pipes passing through the bridge. The Control of Asbestos at Work Regulations (CAWR) [ 26] require authorities or the person controlling premises to have an Asbestos Management System in place, which should be accessible to anyone who will work on or in the premises. Consultation between the Health and Safety Executive and the Highways Agency has indicated that bridges and other highway structures are covered by the concept of premises. However, this may not be the case for other authorities, and should be checked with each individual authority.

3.3.8 The Supervising Engineer has a duty to have in place an Asbestos Management Plan for each structure, unless it has been shown that there is none, and for controlling access to the structure. There must also be a named "Duty-holder" who is responsible for operation of the Asbestos Management Plan and revising it as necessary. The Asbestos Management System and in particular the individual Asbestos Management Plans should enable the inspector to check for the presence of asbestos containing materials prior to the inspection, thereby enabling appropriate action to be taken if or when asbestos is present.

**Personal Safety**

***Personal Care***

3.3.9 Under the *Health and Safety at Work Act* [17], all inspection personnel have a duty to take reasonable care of their own health and safety and that of others who may be affected. Inspectors are also required to co-operate with the Supervising Engineer, the authority's Safety Officer or other competent individuals on health and safety matters. An example of a check list, reminding staff of personal safety matters when working on or off the public highway, is provided in Appendix B.

3.3.10 Inspection of highway structures can be a hazardous operation and, when concentrating on the task in hand, it is easy to be momentarily unaware of danger. Stepping backwards out of a working zone into a live traffic lane is but one example. Inspectors should therefore be alert at all times, developing the ability to concentrate on the task in hand while being aware of surrounding hazards.

3.3.11 Working while under the influence of alcohol or drugs or when tired or ill can impinge on the ability to concentrate which may adversely affect the work and cause danger. When working on or over railways there are strict regulations under the *Transport and Works Act* [27].

3.3.12 Although a high degree of physical fitness is not required of an inspector, a reasonable level of agility and mobility is required. Sufferers of respiratory problems should be aware that they may be in dusty or dirty environments. Those prone to black-outs should not be involved in inspections.

3.3.13 Inspection work may involve contact with dirty surfaces; personal hygiene is therefore important. A supply of soap, water and disposable paper towels is advised. A first aid kit appropriate for the number of staff and nature of likely injuries should be readily available.

3.3.14 The areas under and around highway structures are frequently used for dumping rubbish and considerable debris can collect within a culvert. This ranges from abandoned vehicles to industrial or household waste or discarded hypodermic needles, which may present a wide variety of hazards. Inspectors should therefore avoid handling or disturbing rubbish. Where possible, arrangements should be made for the waste disposal authority to remove it, however, if it is necessary to handle rubbish, the appropriate Personal Protective Equipment (see paragraphs 3.6.28-3.5.29) should be worn. Particular care should be exercised in areas where hypodermic needles or syringes may be encountered.

3.3.15 In such work environments, there is an element of incidental exposure to biological agents, i.e. harmful micro-organisms such as bacteria, fungi, viruses, internal parasites, and other infectious proteins. For example, handling waste contaminated with human/animal waste or working with equipment or in an environment that is contaminated e.g. sewers. Inspectors should be aware that they may be harmed by biological agents by being infected with a micro-organism, by being exposed to toxins produced by the micro-organism, or by having an allergic reaction to the micro-organism or substances it produces. The advice contained in the Health and Safety Executive publication *Infection at work: Controlling the risks* [28] should be followed for the prevention of incidental exposure.

3.3.16 The classification of biological agents is documented in the *Approved List of Biological Agents* [29] which was produced under Section 15 of the *Health and Safety at Work Act* [17]. The Approved List also gives a separate indication of which biological agents are capable of causing allergic or toxic reactions or where there is an effective vaccine available. The *Approved List* should be read in conjunction with *The Control of Substances Hazardous to Health (COSHH) Regulations 2002* [30] and, in particular, Schedule 3 – additional provisions relating to work with biological agents.

3.3.17 Pigeons and other birds sometimes roost or nest on bearing shelves or other remote ledges on bridges, causing an accumulation of bird droppings. Such droppings can harbour parasites or fungal spores and should therefore be regarded as toxic. Suitable respirators should be worn in areas where bird droppings have accumulated.

3.3.18 All staff that may be required to work in or near water or enter confined spaces (especially long culverts) should be warned of the dangers of and be issued with a Leptospirosis (Weils Disease) Card or issued with the HSE Leaflet INDG84 08/06 C500 and be familiar with the relevant control measures.

3.3.19 Inspectors should not undertake work which they consider to be a danger to themselves or others. Thus, they should not attempt work which they believe to be inherently dangerous, nor should they attempt work for which they are not competent through limitations of training, experience or ability, or through ill health. Likewise, they should not attempt work which has not been properly planned, for which an adequate risk assessment has not been prepared, or where there is a lack of the required equipment.

3.3.20 Inspectors should be aware of the procedures to be followed and people to contact in the event of an accident to themselves, their colleagues, or members of the public. It is advisable to consider the need for a member of the inspection team to be trained in first aid. They should also be alert at all times to any situations which may create a hazard and take whatever steps are necessary to ensure that hazards are removed or minimised.

***Electricity***

3.3.21 Inspections and investigations may involve working with electrical equipment – power tools, floodlights, etc. All such work should be undertaken in accordance with the *Electricity at Work Regulations* [31]. Where the electrical equipment operates at 50 or more volts Alternating Current (AC) or 75 or more volts Direct Current (DC), the equipment should comply with the *Electrical Equipment (Safety) Regulations* [32].

3.3.22 In addition, many bridges and other highway structures have electrical equipment attached to them in the form of electricity supply cables, lighting, matrix signals, etc. Inspection work on such structures should comply with the *Electricity at Work Regulations* [31]. Wherever practicable, electrical equipment attached to structures should be isolated or disconnected before carrying out inspections in the vicinity. Inspectors should assume that cables and equipment are live unless they have clear authoritative information that they are not. If an inspector encounters an unexpected cable or item of electrical equipment, they should cease any work which might affect the item and arrange for a suitably qualified and experienced person to identify it. Work should not resume until the suitably qualified and experienced person either has been able to ensure that the item is not live or can confirm that it is safe to proceed with the proposed work. Similarly, if any damaged electrical apparatus is discovered, the inspector should arrange for it to be made safe before proceeding.

3.3.23 The locations of any overhead lines in the vicinity of the bridge should be noted, so that the appropriate precautions can be made to keep all working areas and access equipment safely away from them. The regulations of the relevant authority should be complied with when working near any overhead lines or apparatus.

3.3.24 A further electrical hazard which can occur during inspections is damage to underground cables. Work requiring excavation should not be undertaken without checking for the presence of cables or other buried apparatus, utilising the appropriate cable detection equipment. The structure records (see paragraph 3.7) should be consulted but the relevant organisations should also be contacted for advice on the location of their cables as the structure records may not be accurate. Should it be necessary to excavate near cables or ducts, hand digging should be employed until the services have been exposed. Guidance on working near overhead and underground services is given in the *Construction Health and Safety Manual* [23].

3.3.25 The risk assessment and method statement (see paragraphs 3.2 and 3.4) prepared for an inspection should take account of any potential electrical hazards at the highway structure site.

**Public Safety**

3.3.26 When planning and carrying out inspections at any location, the safety of the public and other third parties must be considered [33]. Traffic management will normally be used to provide safe conditions for motorists, but the needs of pedestrians, cyclists, equestrians and occupiers of adjacent land or property must also be catered for.

3.3.27 It will not always be possible to avoid working alongside or over a route used by pedestrians or cyclists. In these circumstances additional care must be taken and, if appropriate, a lookout should be provided. The lookout's responsibility would be to warn both the public and inspectors of the possible danger. Alternatively, and if appropriate, the working area may be identified by means of stakes and warning tape to fence off the area. Suitable warning signs may also be required.

3.3.28 Pedestrians should not be diverted from their normal routes unless a diversion is clearly designated. It should be checked to ensure it is at least as safe as the normal route. When working above or adjacent to pedestrian routes, great care should be taken to avoid dropping tools or any other item.

3.3.29 In any situation where an inspector considers there will be a danger to third parties if work proceeds, the work should be stopped and further advice sought as to how to proceed safely.

## 3.4 RISK ASSESSMENTS

3.4.1 The *Management of Health and Safety at Work Regulations* [17, 34] require that an assessment is carried out identifying the risks to workers and others who may be affected by undertaking work and to record the significant findings of that assessment.

3.4.2 A Risk Assessment is the systematic process of:

- defining the activity, procedure or situation to be assessed;
- identifying all significant hazards;
- determining the likelihood of harm occurring due to the presence of the identified hazard;

- assessing the consequences of the harm;
- forming a judgement based on the possible consequences that the level of risk is either acceptable or unacceptable; and
- recording the conclusions arrived at and the information on which they were based and, if the risk is unacceptable, revising the method of working until the risk is acceptable or can be adequately mitigated or controlled.

3.4.3 Further advice and guidance may be found in the HSE publications *Five Steps to Risk Assessment* [35].

3.4.4 A risk assessment requires concentration on those risks that are liable to arise because of the work activity. Normally, trivial risks and risks arising from life in general do not need to be recorded unless they are increased by the work activity. A risk assessment should be an aid to the development of safe working practices and not an end in itself. It should not be a task which is out of proportion to the actual work activity.

3.4.5 The assessment should be appropriate to the nature of the work. Where the work activity or work place changes, the risk assessment may need to concentrate more on the broad range of risks that may arise. Risk assessments should be continually reviewed, particularly in the light of comments from persons involved in carrying out the work process.

3.4.6 A risk assessment should always be carried out before commencing work. For example, a risk assessment for a Safety Inspection may be brief and simple, but it must not be omitted. A risk assessment does not easily lend itself to objective numerical analysis. For the purpose of assessing risks associated with inspections, a simple qualitative approach may often be appropriate.

**Preparing an Inspection Risk Assessment**

3.4.7 The main objective of a risk assessment is to establish and record the measures that are to be taken to eliminate or reduce risks to inspection personnel and to members of the public during the proposed activity, and thereby to ensure that those managing or working on the project are provided with the information that they need to work safely. Its secondary objective is to provide evidence of compliance with legislation. There are no official requirements as to the form that a risk assessment should take. However, the *Approved Code of Practice* [21] provides guidance.

3.4.8 Some inspections will require staff with very specific safety training. Examples are access to railways, working in confined spaces and working at heights. Any such requirements should be identified and specified in the risk assessment.

3.4.9 There is bound to be some similarity between inspection projects and it is often appropriate to use generic or earlier risk assessments as guidance. However, it is not sufficient to just change the heading, date, address and the names. If the procedure is to have any real value, original thought should go into each project. For this reason, check lists should be used with care: although they provide a convenient reminder of most risks, they will not necessarily identify unusual hazards. The assessment should cover risks to the workforce and the public, with particular attention given to pedestrians and to vehicle, waterway and railway traffic as appropriate. Where the assessment identifies particular problems for health and safety, a detailed statement should be prepared covering the procedures to be adopted to minimise risks.

3.4.10 The best results are often achieved when at least two people work on a risk assessment, especially when identifying hazard and developing mitigation or control measures, as discussion often triggers new thoughts. It is also helpful to involve the people working on the project by allowing them to produce a draft version. Where appropriate, the highway authority's Safety Officer, the Health and Safety Executive, the police and other interested, expert or competent parties should be consulted.

3.4.11 It may often be appropriate to combine the risk assessment with some other document or report such as a health and safety plan or method statement. These three documents are closely related and in some cases there may be a considerable degree of overlap. The most appropriate format will depend on the nature and size of the inspection.

## 3.5 METHODS OF ACCESS

3.5.1 When planning any inspection, careful thought should be given to the methods of access required. This would generally require consideration of the types of access equipment to be used, the restrictions or obstructions caused by the equipment, traffic management requirements, and the routes to be used to and from the highway structure site. Consideration should be given to the items listed in Table C.6 with regards to where and when will access be needed and how will it be achieved.

| **Table C.6 – Access considerations** |
|---|
| **Where** |
| • from highways (see paragraphs 3.5.4-3.5.15);<br>• away from highways (see paragraphs 3.5.16-3.5.20);<br>• at or over railways (see paragraphs 3.5.21-3.5.22);<br>• in or over water (see paragraphs 3.5.23-3.5.29);<br>• underwater (see paragraphs 3.5.31-3.5.41);<br>• in confined spaces (see paragraphs 3.5.42-3.5.54);<br>• in environmentally sensitive areas (see paragraph 3.11); |
| **When** |
| • during short term possessions (see paragraphs 3.5.5-3.5.15 and 3.5.21);<br>• between tides (see paragraphs 3.5.31-3.5.41);<br>• to avoid disturbance to agriculture (see paragraphs 3.5.16-3.5.20);<br>• to avoid disturbance to wildlife (see paragraph 3.11);<br>• at night (see paragraphs 3.5.55-3.5.61) |
| **How** |
| • what access equipment will be needed (see paragraphs 3.6). |

3.5.2 Safety of the inspectors and the public must always be considered as an integral part of these deliberations. A pre-inspection visit to the site is recommended prior to undertaking Principal Inspections and, where appropriate, Special Inspections.

3.5.3 Some of the following sections provide guidance on the selection of the appropriate access equipment and on safe methods of working. Further advice is given in *Temporary Access to the Workface* [36].

**Working on Highways**

3.5.4 Many inspections require some of the work to be carried out from the carriageway, hard shoulder or verge. Particular care must be taken to ensure the safety of both the inspectors and the public. All personnel working within the highway boundary should normally wear high visibility outer clothing except when in a vehicle. Particular access issues that should be considered when undertaking inspections on or near the highway include traffic management, mobile land closures, single vehicle works, and inspection from the verge; guidance on these is provided below.

***Traffic Management***

3.5.5 Restrictions to any part of the carriageway or motorway hard shoulder should be set out and signed in accordance with the relevant provisions of Chapter 8 of the *Traffic Signs Manual* [37, 38], *Approved Code of Practice for Safety at Street Works and Road Works* [39] and Volume 8 of the *DMRB* [40]. Recommendations on factors which should be taken on board when planning, executing and removing of traffic management are given in the Chapter 8 of the *Traffic Signs Manual* [37, 38] and should be considered where appropriate.

3.5.6 Where reasonably practicable, inspections should be designed to avoid or minimise the need for traffic management. However, the safety of the inspection team should be balanced against the convenience of the motorist. On busy roads, inspections may need to be carried out at times of minimal traffic flow, such as at night or early on Sundays. When designing traffic management for all-purpose roads, the needs of motorists, pedestrians and other users should be catered for.

3.5.7 Where access to undertake an inspection requires traffic management on a road owned by another authority (be it major road, minor road, or a private road or track), the traffic management arrangements should be agreed with the owner. Even on minor tracks, warning signs and protection may sometimes be needed (also see paragraphs 3.3.26-3.3.29).

3.5.8 While working within a lane closure or other form of traffic management, the inspector should ensure that an adequate safety zone is maintained between working and trafficked areas. Vehicles and equipment should be sited as far from the live carriageway as practicable – preferably off the highway altogether. Where it is necessary to park vehicles or plant on a closed area of carriageway, it is advisable to site them ‘upstream’ from the work site. Front wheels should be turned towards the verge. Access equipment should never be allowed to overhang any live traffic lane or safety zone; particular care should be taken when using equipment with articulated booms. Safety zones should be arranged around the area of working, not only to protect any aerial equipment but also to avoid injury to passers-by if a hammer or other item should fall.

### *Mobile Lane Closures*

3.5.9 Mobile lane closure is a technique for use on dual carriageway roads whereby an operative works, stopping if necessary, ahead of suitably equipped lane closure and blocking vehicles. The blocking vehicles are fitted with direction arrows, beacons and crash cushions. Mobile lane closures should be carried out in accordance with Chapter 8 of the *Traffic Signs Manual* [37, 38].

3.5.10 Mobile lane closure is suited to short duration activities at carriageway level. Without mobile lane closure it would often be necessary to cone off a length of carriageway. Training of all personnel involved is essential, as is the need to adhere exactly to the required procedures.

### *Single Vehicle Works*

3.5.11 Inspection work requiring the inspector to work on or close to the carriageway may sometimes be carried out using a single vehicle standing or operating on the carriageway. However, this method of working should only be adopted after a thorough risk assessment including consideration of alternatives. Vehicles should be positioned 'upstream' of the working area and all personnel should wear high visibility outer clothing.

3.5.12 Single vehicle works should never be used on unrestricted dual carriageways without hard shoulders; instead, works should be carried out by static traffic management or a mobile lane closure.

### *Inspection from the Verge or Adjacent Earthworks*

3.5.13 Inspections are frequently carried out using personnel or equipment on the verge or adjacent earthworks – within the highway boundary but off the carriageway. The work ranges from visual inspections on foot to detailed testing requiring access and other equipment. The duration of the work may vary from a few minutes to several days.

3.5.14 The risks of working close to live traffic lanes should always be considered. Even when working clear of the carriageway, there may be a need for some encroachment onto the hard shoulder or traffic lanes. Examples include parking the inspectors' vehicles, while gaining access or egress, manoeuvring plant into position, or while moving from one side of the structure to the other. Appropriate traffic management should be installed in all cases; this will normally require a lane closure (see paragraphs 3.5.4-3.5.8).

3.5.15 When inspecting on foot from the verge or adjacent earthworks on a motorway, the inspector's vehicle may stop on the hard shoulder as described for single vehicle works (see paragraphs 3.5.11-3.5.11). On roads without hard shoulders, stationary vehicles should be parked off the carriageway wherever possible. A convenient lay-by or field gate entrance should be used if available, or the vehicle may stop on the verge. If it is necessary to stop on the carriageway, the vehicle should be parked as close to the edge as possible. Providing visibility is adequate, it is generally preferable to stop on a minor road rather than the main road. Vehicles should generally be positioned 'upstream' of the working area. Where possible, the inspector should seek to avoid the need to work from or to cross the carriageway.

**Off-Highway Working**

3.5.16 Wherever practicable, inspection work should be carried out off the highway (i.e. outside the highway boundary), with access equipment and vehicles also sited off the highway. Permission for access should be obtained from landowners or occupiers, and ground conditions may need to be checked.

3.5.17 Off-highway, pedestrian or vehicular traffic may use the area, so suitable barriers or warnings should be considered. Similarly there may be a need to fence the working area against livestock. The requirements of vehicles, pedestrians and livestock should be taken into account; accesses, rights of way or entrances should not be obstructed without first consulting and agreeing with the appropriate individuals or organisations (also see paragraphs 3.3.26-3.3.29).

3.5.18 Access routes to and from the highway structure site should be chosen so as to minimise damage or disruption; agreement with the landowner or occupier will generally be required. Where it is necessary to cross, or work on or adjacent to, agricultural land, special requirements may be needed to avoid the spread of animal or plant diseases. These should be ascertained and abided by. Care should also be taken to avoid permitting livestock to stray. Where appropriate the *Countryside Code* [41, 42, 43, 44] should be followed.

3.5.19 At some sites there may be features of ecological or landscape significance. Good working practices should be adopted at all times, in particular to avoid pollution of watercourses, and special procedures followed whenever required (see paragraph 3.11).

3.5.20 Despite being close to in service roads and possibly populated areas, some locations around highway structures should be regarded as ‘remote areas’. For example, a person lying injured by a culvert headwall at the foot of a highway embankment could remain undiscovered for a long time. Inspectors should be aware of areas which may effectively be remote and should follow the authority’s procedures when entering such areas. These procedures will usually prohibit anyone from entering a remote area alone without first notifying others. Mobile telephones can be particularly useful for obtaining help in an emergency. In some rural areas, however, it may not be possible to use mobile phones due to lack of network coverage. Therefore as part of planning an inspection, the coverage of the particular phone that will be used by the inspector should be checked.

**Working on or over railways**

3.5.21 Railways are hazardous places. Consequently, the railway authorities have strict rules governing access onto and over their property; unauthorised entry is illegal. Early consultation with the railway authority is essential, as obtaining permission for entry or a track possession can be a lengthy process. Track possessions can normally be obtained only for short periods, usually at night or during a Saturday night and Sunday morning. Track possessions for bridge inspections are often scheduled to coincide with other maintenance work on the line.

3.5.22 Railway authorities produce their own safety procedures to be adopted when working on or near their lines. In general, work on or near the line is carried out in an area safeguarded by either stopping all trains, fencing off from lines in use, or being separated by a minimum distance from lines in use. Outside of these areas work is only undertaken when absolutely necessary and when lookout protection is provided. The specific procedures of the relevant railway authority must be adhered to in all cases.

**Working in or over water**

3.5.23 Working in or over water presents the risk of drowning; people can drown even in small watercourses. Therefore, precautions should be taken to prevent persons from tripping, falling or being swept into water. Platforms and gangways must be secure and protected with guardrails and toe boards. Allowance should be made for tidal range or any other variation in water level.

3.5.24 Safety harnesses and life jackets or buoyancy aids should be worn where appropriate. Lifebuoys or rescue lines should be readily available close to a working area over water and a rescue boat should be on active stand-by in deep water.

3.5.25 Inspection of some low headroom structures over watercourses may be carried out using a dinghy or other suitable craft. It is often most appropriate to use an inflatable, flat bottomed craft as these provide a reasonably stable platform. If inspections are carried out from a boat the inspector should be accompanied by a second person who is in sole charge of the craft. The craft should be positioned under the structure by means of fixed lines attached to the structure or bank or anchors. The craft should not normally be maintained in position during the inspection through the use of its engine. The standard of control of the craft is crucial to its safety and in most cases should only be undertaken by experienced boatmen.

3.5.26 Structures over navigable waterways may often best be inspected from an access platform mounted on a barge. This is a specialised means of access, which should be undertaken with great caution and only under the instruction of a person or organisation experienced in this form of access. At all times during the inspection, a rescue craft should be in attendance with fully equipped and trained personnel on board. The need for a rescue boat may be forgone if a risk assessment shows that this is unnecessary, e.g. on quiet canals.

3.5.27 It may be appropriate for the inspector to enter shallow water wearing wellington boots or waders. However, great care should be exercised due to the possibility of unseen hazards (glass or other debris, tree roots, scour holes, etc.), soft mud or slippery surfaces. The difficulty of keeping firm footing in fast flowing water should not be underestimated. A wading pole should always be used to test the depth of water. Waders should be used with special caution; in the event of falling over in the water, the waders may float, inverting the wearer and making it difficult to regain an upright posture. For this reason, thigh waders are safer than waist or chest waders. In deep water – over 1m deep – or if it would be necessary for the inspector to put his face underwater, the inspection of areas underwater should only be carried out as an underwater inspection (see paragraphs 3.5.31-3.5.41).

3.5.28 Wet or muddy surfaces can be extremely slippery and venturing onto such surfaces should be avoided if possible.

3.5.29 Waterways are administered by a number of bodies including the Environment Agency, British Waterways, Waterways Ireland, local authorities and harbour authorities. The appropriate body should be consulted in case there are any special requirements to be considered.

3.5.30 Inspection of culverts should always be undertaken with great care with the possibility of flash floods and accidental discharges into the watercourse being taken into account. Where significant water flow is unavoidable, the water is deep or there is low headroom, the inspection should be treated as an underwater inspection (see paragraphs 3.5.31-3.5.41). In rare cases, the inspection of the culvert above water level may be undertaken from a boat.

**Working Underwater**

3.5.31 Underwater parts of structures will require inspection from time to time. Typical reasons are to investigate the presence or extent of scour, either as a routine precaution or following a flood, or to ascertain the condition of underwater parts of the structure. In many cases the inspection will include structures such as retaining walls and adjacent areas of the bed of the watercourse.

3.5.32 Underwater inspections are potentially hazardous and can be very expensive, so it is important to plan adequately. Much of the planning and associated risk assessment will require similar consideration to any other inspection; however, the following aspects (inspection information, scheduling, lowering the water level, diverting the watercourse and diving) should be subject to particular consideration. Further guidance on underwater inspections is provided in the *Guide to Inspection of Underwater Structures* [45].

***Inspection information***

3.5.33 The Supervising Engineer should provide those undertaking the inspection with as much information as is reasonably possible concerning the underwater parts of the structure and the watercourse. Sources of information may include, but are not restricted to:

- Previous inspection records and where available risk assessments indicating known or suspected hazards such as restricted access, fast currents or high turbulence, contaminated water, vessel traffic, low visibility and low temperature.
- Drawings of abutments, piers etc., especially those showing depth and shape of foundations, type of construction etc.
- A sketch of the structure identifying abutment and pier numbers, directional identification (from-to), flow direction and limits of examination e.g. all parts of the structure which are at bed level or which extend over the bed. These include inverts, aprons, revetments, scour protection works etc.
- Details of all parts of the structure between bed level and High Water level. This will include parts of the structure which are accessible without divers at certain states of tide or time of year, but which are considered to be included as "underwater parts" of the structure.
- Location and value of reference datum for a scour survey.
- Data of previously measured bed levels, either original or from previous examinations.

### *Scheduling*

3.5.34 Unless the inspection is required urgently, it may be possible to time the inspection to coincide with favourable conditions such as low spring tides or low river flow. For example, inspection of culverts should normally be undertaken at the end of a long dry spell such that the flow of water is at its minimum. Refer to Section 2.4 for guidance on scheduling inspections.

Lowering the water level

3.5.35 The possibility of lowering the water level should be considered, so as to expose part, or all of the areas, which require inspecting. In canals or some rivers it may be possible to drain the water or reduce levels, however, this should only be undertaken following consultation with the relevant organisations since draining can have a variety of harmful effects along the stretch of watercourse. Local dewatering, using a cofferdam, flexible dam or limpet dam, may be a practicable alternative. If, after any reduction in water level, the inspector would still need to enter water deeper than 1 m – or immerse their face underwater, qualified divers should carry out the inspection.

### *Diverting the watercourse*

3.5.36 It may be practicable to dam the watercourse and divert the flow. This approach may be beneficial for enabling the inspection of some culverts. The environmental implications associated with diverting the watercourse should be carefully considered, and the potential for causing flooding on the diversion course. Diversions are best undertaken in times of low water flow.

### *Diving*

3.5.37 Carrying out effective underwater inspections requires considerable experience on the part of the diver. Underwater it is rarely possible to view the structure as a whole; orientation and location can be difficult to determine. The divers should preferably have relevant civil or structural engineering experience in addition to diving qualifications.

3.5.38 All diving operations in the UK are covered by the *Health and Safety at Work Act* [17, 46], the *Diving at Work Regulations* [47], and the *Approved Code of Practice for Commercial Diving Projects* [48]. All divers involved in commercial operations are required to hold valid diving medical certificates, a completed log book, a Health and Safety approved diving qualification and a valid HSE Diving First Aid Qualification; The Statutory Instrument lays down four main categories of diver qualifications. For most cases of underwater inspection for highway structures the minimum qualification would be HSE Part IV which covers diving to 30m using air alone.

3.5.39 Diving contractors undertaking underwater inspections should hold a HSE approved Diving Procedures Manual and be registered with the Health and Safety Executive. The *Diving at Work Regulations* [47] require diving contractors undertaking underwater inspections to prepare a job specific diving plan. A separate risk assessment for non-diving activities may need to be prepared in accordance with the *Construction (Design and Management) Regulations* [16].

3.5.40 The diving team should normally comprise a minimum of three HSE qualified divers: a diving supervisor, a working diver and a stand-by diver. However, depending on the nature of the diving operation, the use made of mechanized equipment and hazards, additional divers or other personnel may be required.

3.5.41 A wide range of inspection, measurement and testing techniques may be used underwater, including both still and video photography. However, the detail which can be determined and the accuracy of location are both hampered by the conditions. Even in good visibility, a close visual inspection cannot be relied upon to detect cracks less than 3mm especially where marine or aquatic growth is present. Where there is little visibility, the diver may have to rely on touch instead of sight: in these conditions only gross faults such as voids or cracks greater than 25mm width would be detected.

**Working in Confined Spaces**

***Types of Confined Spaces***

3.5.42 A 'confined space' is not readily defined as it does not always have to be enclosed on all sides; for example an open topped access shaft is a confined space. Confined spaces are typified by restricted access and space, poor ventilation and the lack of oxygen or presence of harmful gases. Workers in confined spaces may not be aware of the danger, for example when oxygen is gradually replaced by other gases. Examples of confined spaces are:

- interior of box girders and bridge towers;
- cofferdams and caissons;
- pumping station wells;
- sewers and manholes;
- culverts, pipelines, headings, tunnels, and shafts;
- bored piles, wells, tanks, ducts, silos, valve pits, excavations and trenches.

3.5.43 Excavations and trenches are included in the examples of confined spaces in the above list as particularly in the case of chalk excavations there is a possibility of oxygen deficiency due to acidic attack. In addition excavations and trenches may have restricted means of egress.

3.5.44 Confined spaces may be attractive to children, vandals and others. It is therefore essential that measures are taken as far as reasonably practicable to prevent unauthorised entry. Further advice is given in the *Approved Code of Practice to the Confined Spaces Regulations* [49].

***Hazards***

3.5.45 Hazards which may be present in confined spaces include:

- oxygen deficiency or excess;
- toxic fumes, including gases and vapours;
- flammable gases or liquids;

- fire;
- dust;
- bacteria or fungal spores;
- vermin;
- water;
- restricted and delayed egress in an emergency.

3.5.46 Hazards associated with a confined space often can be exacerbated by the work being undertaken within them. For instance the adverse effect on health due to fumes or gases produced by welding, flame cutting, painting and use of solvents are all greater in a confined space, an example being the removal of lead paint from surfaces in a box girder. In the case of a visual inspection it should not be assumed that there will be no additional hazards, as for example disturbance of stagnant deposits when moving about in a culvert or sewer may lead to the release of gases. Inspectors should also be aware that the 'normal' hazards encountered in inspection work can be more difficult to deal with in a confined space.

3.5.47 Whenever mould growth is encountered in a box girder or similar location, it should be treated as toxic and all inspection work should cease until the level of toxicity has been established as being within safe limits. Advice on safety should be sought from the Health and Safety Executive.

***Confined Space Working***

3.5.48 All work in a confined space should be considered as potentially dangerous and a carefully organised approach is therefore required, using a permit to enter/work system. A permit to work sets down in detail the work to be done and the precautions needed before entering and during any time spent in the confined space. As part of the permit to work it is usual for a permit to enter to be specified for the control of entry. However, the fact that such a system is adopted does not guarantee safety.

3.5.49 A permit to work system should include such topics as work activities, sequence of work, responsibilities, atmospheric testing and monitoring, personal protective equipment and other equipment, ventilation, communication, methods of entry and exit, lighting and, most importantly, emergency rescue procedures. The permit should be prepared by a competent authorised person familiar with the hazards and risks associated with the work. A sample Permit to Work is provided in Appendix C.

3.5.50 Whenever possible additional hazards should not be introduced into confined spaces. As an example, if a petrol driven generator is required this should be kept outside in a well ventilated area with the exhaust directed away from the entrance. Likewise where substances which give off vapours are proposed, alternative materials should be considered. Anyone who does not have a genuine need to enter a confined space should not do so as their presence may increase the risks involved.

3.5.51 The Supervising Engineer should compile and maintain a list of structures, or parts of structures, which are considered to be confined spaces. The list should be agreed with appropriate personnel and all relevant parties made aware of the list. Adequate risk assessments and method statements (including emergency procedures) should be prepared before any work requiring entry is undertaken (see paragraphs 3.2 and 3.4). Following the assessment of the risks involved in entering a structure, it may be decided to limit entry only to those staff issued with a permit-to-work (see Sample Permit to Work, Appendix C).

3.5.52 A safe system of work must be prepared and an assessment of the risks involved made for the entry requirements for each confined space and for each mode of entry. Requirements may be different, in the same space, at different times or for different purposes. All parties should be made fully aware of the requirements. Staff should be given appropriate training before they enter confined spaces.

3.5.53 Staff should be provided with personal protective equipment (e.g. helmets, goggles, gloves, overalls, masks) and safety equipment (e.g. safety harness, rope and attachment, gas tester, torch breathing apparatus) appropriate to the requirements of each structure. Communication equipment should also be provided where necessary. Periodic checks should be made to ensure the equipment is functioning correctly.

***Classification of Confined Space Working***

3.5.54 In order to assist in the identification of confined spaces and the development of the required system of work, confined space working can be divided into three main classes as described below.

- ***Class A Working*** – Class A working is for use for inspection work where it is possible to see the inspector working and there is ready communications. In some situations personnel winching may be required. A typical arrangement for inspection of a manhole chamber is shown in Figure C.2. A minimum of two personnel are required for Class A working. Depending on the confined space depth and associated hazards, it is recommended that equipment should include but not be limited to: gas detector; personal protective equipment; communications; harness; life lines; lighting; riding winch; escape breathing apparatus; resuscitator.

- ***Class B Working*** – Class B working is for use for inspection work where an intermediate person is required to maintain audible or visual communications. In some situations personnel winching may be required. A typical arrangement for the inspection of a culvert accessed from a manhole is shown in Figure C.3. A minimum of three personnel are required for Class B working. Equipment required would be the same as for Class A working. Particular consideration should be given to the provision of escape breathing apparatus which would be required if the total distance to safe atmosphere may be of some distance.

- ***Escape breathing apparatus for Class A & B Working*** – Consideration should be given to the type of escape breathing apparatus to be used. For example, would a 10 minute escape set be sufficient, or should alternative temporary equipment (sufficient for an escape) be provided? It should be noted however, that Class A and B Working excludes the provision for the use of 30 minute breathing apparatus. This is subject to sub-section 4 and 5 of Section 30 of the *Factories Act* [13].

- ***Class C Working*** – Class C working is for use for inspection work where Class A & B are not appropriate and for other types of more hazardous activities such as testing, investigations and minor reinstatements. Typical arrangements are shown in Figure C.4 for situations where it is possible to see the inspection team and there is ready communications and in Figure C.5 where this is not possible. A minimum of four personnel are required for Class C working and typical equipment would include gas detection (minimum 2); personal protective equipment; communications; harness; life line; lighting; riding winch (dependent on depth); resuscitator; first aid kit; air mover; escape breathing apparatus; 30 minute working breathing apparatus, etc. However, the number of personnel and type of equipment to be provided will be dependent on the risk activity. In order to determine resources, this type of work should be carefully planned, with the risks being assessed and written safe system of work produced. For example, on a large project, such as extensive investigation and testing in a long box girder, consideration should be given to the placing of kits of additional rescue, breathing and resuscitation equipment at strategic points and arranging for these to be suitably marked and signposted.

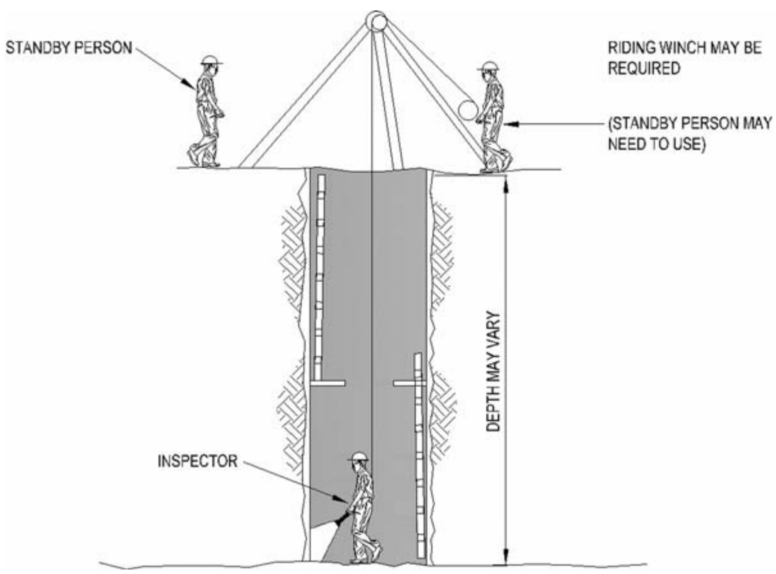


**Figure C.2 – Confined Space Working: Class A**

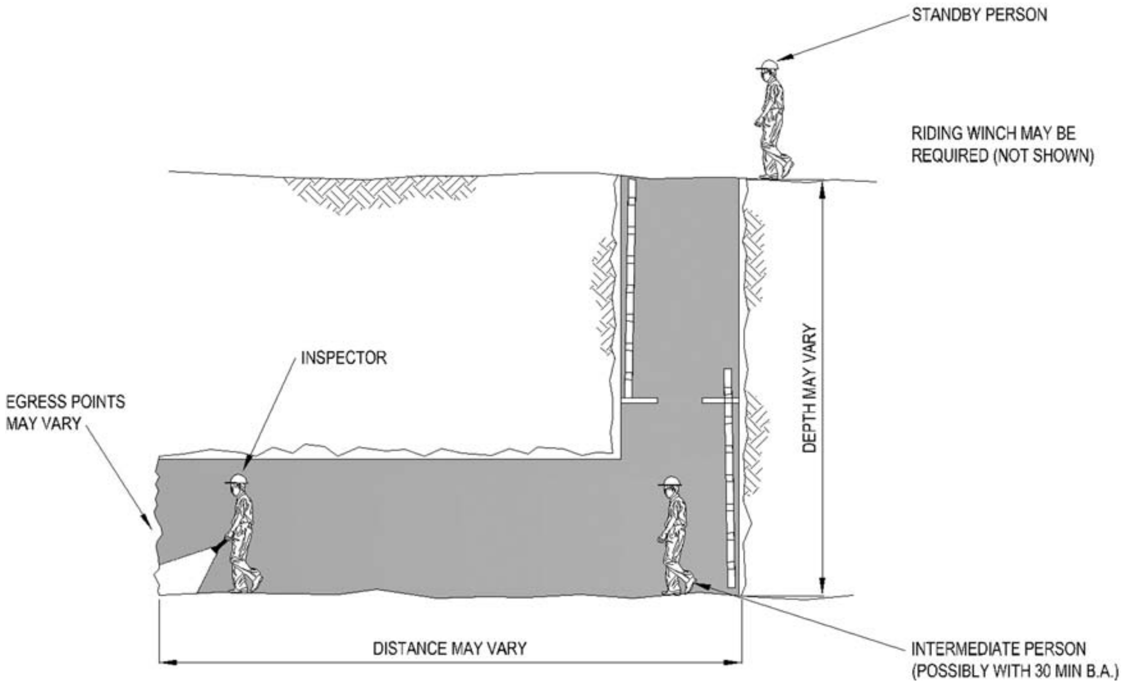


**Figure C.3 – Confined Space Working: Class B**

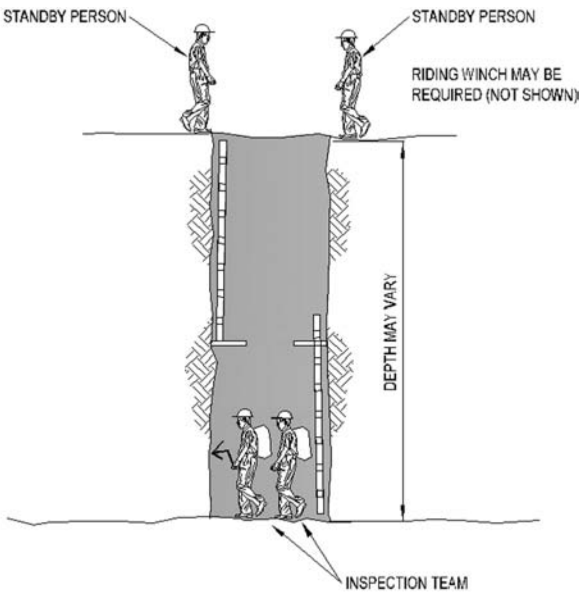


**Figure C.4 – Confined Space Working: Class C1**

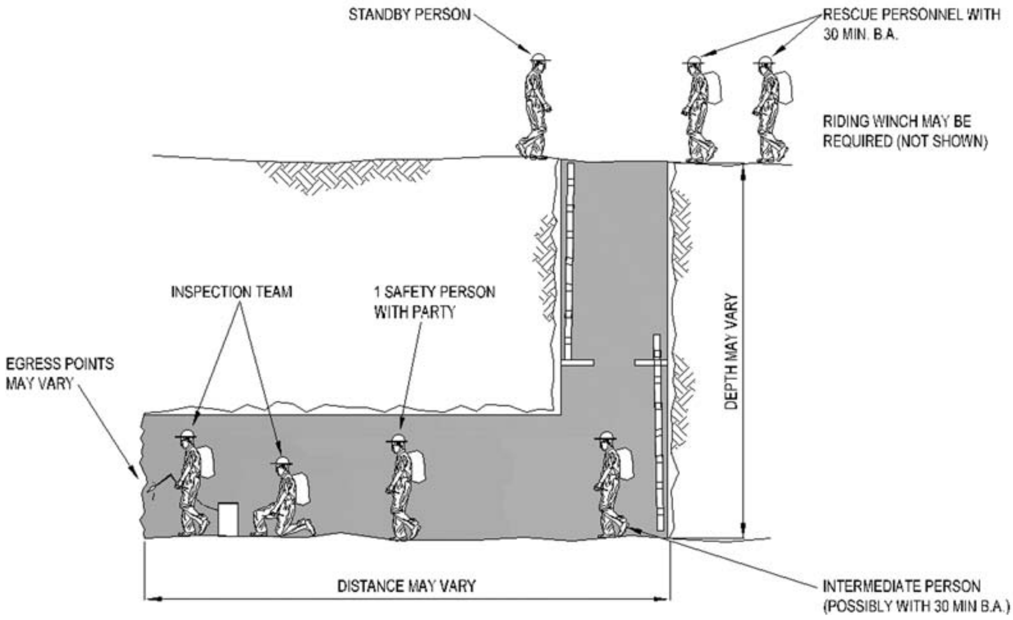


**Figure C.5 – Confined Space Working: Class C2**

**Night-Time Working**

3.5.55 Inspecting at night, on carriageways which are heavily trafficked during the day, can greatly reduce the delays and disruption caused by traffic management. With night-time only working, lane closures are introduced after the evening peak traffic flow and removed before the build-up of the morning peak flow. Chapter 8 of the *Traffic Signs Manual* [37, 38] contains useful advice on night-time working.

3.5.56 Night time working is not generally appropriate for General Inspections as normally at such inspections no traffic delays are incurred and there may be practical difficulties in providing the required luminance to surfaces not closely accessed.

3.5.57 Working at night is inherently more dangerous than working during the day. The additional risks may include working in darkness or restricted lighting, fatigue, un-natural work cycles and working at low temperatures. Also, although traffic flow is reduced, lighting and signing of the traffic management needs special care to reduce the risk of accidents due to darkness. A risk assessment (see paragraph 3.4) that takes into account these additional factors should be prepared and appropriate mitigation measures identified.

3.5.58 It is important to ensure that staff working at night has properly rested before starting work. It is dangerous for staff to do a day's work then, after only a short break, carry on working at night.

3.5.59 When planning night-time working it is essential to provide sufficient resources to ensure that the work can be completed and the road reopened by the due time. The direct costs of the inspections can be higher than daytime working due to reduced productivity and the costs of additional lighting or other equipment. However, the reductions in traffic delay provide substantial benefits on busy roads.

3.5.60 Night-time working should be considered wherever it is a safe, practicable option, for example on dual two-lane carriageways with a daily flow of over

40,000 vehicles and dual three-lane carriageways with a daily flow of over 60,000 vehicles.

3.5.61 Night-time working can be highly disruptive for local residents as the public perception of noise and light is often considerably more acute at night (see paragraph 3.11). The environmental health department of the authority should be consulted in appropriate cases. Advance publicity can significantly reduce potential distress and eliminate complaints.

## 3.6 EQUIPMENT

3.6.1 Part of planning an inspection involves ensuring that the inspector is appropriately equipped for the type of inspection to be undertaken. The inspection team should ensure that all required access equipment, personal protective equipment, data recording and measuring equipment is available and is functioning correctly. Table C.7 lists typical equipment to consider.

| **Table C.7 – Suggested checklist of inspection equipment** (continued) | |
|---|---|
| **Access Equipment** | |
| • ladders<br>• scaffolds | • mobile elevating work platforms |
| **Personal protective equipment** | |
| • personal protective clothing and other equipment<br>• simple hand washing equipment – water, soap, towel<br>• first aid materials | • haversack or shoulder bag for equipment (to leave both hands free)<br>• mobile telephone or other means of communication |
| **Data recording equipment** | |
| • clipboard with waterproof covering<br>• inspection sheets/pro formas or report forms<br>• pocket tape recorder<br>• mobile phone camera | • writing and marking materials (pen, pencil, eraser, chalk, permanent marker)<br>• data logger or notebook computer<br>• digital camera and spare memory<br>• video camera |

Continued

| **Table C.7 – Suggested checklist of inspection equipment** (continued) | |
|---|---|
| **Measuring or inspection equipment** | |
| • cover meter – for depth to reinforcement | • access keys |
| • surface temperature thermometer | • manhole key |
| • steel rule or straight edge | • steel thickness gauge |
| • tell-tales or gauge points – with adhesive | • pen-knife |
| • Demec gauge | • hand held GPS device which can display coordinates |
| • underwater probing rods or ranging rods | • laser measuring equipment |
| • feeler gauges | • Binoculars |
| • Endoscope | • small inspection mirror |
| • steel tape – 3m or 5m | • light tapping or chipping hammer |
| • plumb bob and string line | • screwdriver – for prodding |
| • visual crack-width gauge | • paint thickness gauge; |
| • spirit level | • torch, handlamp or helmet mounted lamp |
| • level and staff | • measuring wheel |
| • hand drill for concrete dust sampling | • telescopic staff – for measuring headroom |
| • phenolphthalein indicator for carbonation tests | |

**Access Equipment**

3.6.2 A preliminary visit to the highway structure site may be necessary in order to determine what form of access equipment is required; what restrictions or obstructions there are; and how the equipment will be transported to and from the site. The area around, over or under the highway structure should be observed, to identify any obstructions such as overhead lines, trees, lighting columns, etc., which could restrict the use of equipment. Ground conditions should also be considered, since poor ground can affect the mobility of access equipment or vehicles and may not be capable of supporting vehicle or outrigger loads.

3.6.3 In some circumstances it may be necessary to check for the presence and location of underground services (see paragraph 3.10.3). Underground services may limit the positioning of equipment and restrict the methods used for digging trial excavations.

3.6.4 Overhead electrical equipment, such as overhead line equipment on electrified railways and high and low voltage electricity distribution lines, present special hazards. Any work in the vicinity of such equipment should comply with the requirements of the relevant authority, e.g. railway authority, electric company.

3.6.5 Equipment to gain access for inspection includes ladders, scaffolds, mobile elevating work platforms (MEWPs), abseiling and walkways or mobile gantries permanently fixed to the structure. All involve working at height above ground level and, as such, present hazards but, with sensible care, the risk of accident can be reduced to an acceptable level. Inspectors should never use any access equipment alone. The guide *Temporary Access to the Workface* [36] provides practical information on the various means of access.

3.6.6 The means of access has an important influence on the safety of an inspection; it is the need for personnel to gain access to a particular point which creates most of the risks associated with inspection. It can be difficult to gain access safely to some parts of a highway structure. In such situations the risks involved need to be balanced against the value of the information. The Supervising Engineer should consider:

- Is the information really necessary?
- Can it be obtained in some other way that reduces risks?
- Will it influence decisions on the maintenance required and/or management strategy?

3.6.7 Deciding who needs to have access may influence the method chosen. For example, if the Supervising Engineer or a specialist needs to see a particular defect personally, scaffolding or a MEWP may be required, whereas, if a photograph will suffice, it may be better to use abseiling.

3.6.8 The following sections outline the principal forms of access equipment, commenting on matters relating to inspections. They do not contain full guidance for the safe use of the various kinds of equipment as such guidance can be obtained from a variety of sources, including those listed in Section 7. When working at height all inspection personnel should comply with the Work at *Height Regulations* [50].

**Ladders**

3.6.9 Ladders are the simplest form of access equipment. They should normally be used as a means of gaining access to an inspection area rather than inspecting from the ladder. However, ladders can be appropriate for 'point' inspections, where there is a need to look at specific small location and/or defect.

3.6.10 If using a ladder to gain access, it should project a minimum height of 1.05m above the landing unless there is another secure handhold immediately adjacent. When using a ladder, inspectors should never lean out from it and should never carry objects while ascending or descending. It is recommended that any equipment required for the inspection is carried in a haversack or shoulder bag leaving both hands free for the ladder.

3.6.11 Stepladders and trestles are not generally suitable for access purposes and should be used with caution, although they can be appropriate for inspecting structures such as pedestrian subways. Further guidance on the safe use of ladders and step ladders in contained in the *Health and Safety Executive Guide INDG 402* [51].

**Scaffolds**

3.6.12 Although a properly erected scaffold can give good access to a highway structure it can also obstruct sight of, or access to, defects in the structure. Ideally a scaffold should be tied to the structure. The erection of scaffolding should be planned properly to ensure that it meets working requirements, is designed to carry the necessary loadings and complies with the requirements of the *Construction (Health, Safety and Welfare) Regulations* [17]. Members of the public should not be put at risk. All scaffolding should be erected, altered or dismantled by trained and experienced persons, who must be under competent supervision. Barriers or warning devices must be placed around the base of a scaffold to prevent collision either by vehicles or by persons.

3.6.13 Scaffolds should be checked before every use for vandalism or unauthorised removal of parts and tagged (to specify the safe working load). Responsibility for the inspection and maintenance of scaffolding should be assigned to a suitably experienced and qualified person, whose duty should include the completion of inspection reports as required by the *Construction (Health, Safety and Welfare) Regulations* [17].

3.6.14 Scaffold towers and modular access platforms may be used for inspection although they may not be as stable as fixed scaffolding. The maximum height of the topmost platform is 3.5 times the minimum dimension of the base. The base may include outriggers if they are firmly in contact with the ground on a firm base or sole plates. In high winds kentledge or guys and ground anchors should be attached.

**Mobile Elevating Work Platforms**

3.6.15 Mobile elevating work platforms (MEWPs) are lorry mounted or self-propelled articulated or telescopic boom type machines. Most types are designed to stand below a structure and reach up to give access to the underside and sides. However, some machines are designed to stand on a structure with booms which telescope out, down and under the same structure.

3.6.16 All MEWPs used for the inspection of highway structures should comply with *BS EN 280* [52]. Operators should be competent and hold a relevant certificate of training achievement issued by either the Construction Industry Training Board or the International Powered Access Federation. The recommendations contained in the *HSE booklet HS(G)19* [53] should also be complied with.

3.6.17 Each MEWP should be inspected by a suitably qualified and experienced person in accordance with clause 7.1.1.5 of *BS EN 280* [52], within the preceding 6 months and following any modification, maintenance or repair which could affect its stability, strength or performance. Each MEWP should also be load tested within the preceding 12 months in accordance with clause 6.1.4.3 of *BS EN 280 [52]*.

Facelift (GB) Ltd

3.6.18 Each MEWP should be fitted with dual controls such that it can be operated through its full working envelope from either the work platform or the ground. At each location where the MEWP is to be operated and prior to its use, it should be tested using ground level controls to demonstrate that it operates smoothly for all practicable motions and that all safety devices work correctly.

3.6.19 The work platform of each MEWP should be fitted with clearly marked safety harness attachment points that are sufficient for the number of persons that could be carried by the platform.

3.6.20 Inspectors should wear a climber's helmet and safety harness when working on a MEWP (see paragraphs 3.6.28-3.5.29). The safety harness should be connected by lanyard to one of the platform's attachment points and to no other position. If the inspector needs to exit from the platform at height a second lanyard should first be secured to a suitable part of the structure before releasing the original lanyard. The work platform should be positioned such that one side is reasonably parallel and close to the structure and at such a height as to facilitate movement from the platform to the structure. The MEWP should never be allowed to overhang live traffic lanes or the safety zones.

3.6.21 Self propelled scissor-type MEWPs are not appropriate for use in many outdoor situations. Most are designed for use only on hard level ground and are suited for use inside buildings, e.g. operating on floor slabs. Self-propelled scissor lifts are not generally as stable as lorry-mounted MEWPs: there can be a serious danger of overturning if they are operated out of level or in windy conditions. Ground conditions must be good enough to support the wheels without settlement. If outriggers are fitted, it may be necessary to use suitable strong packing to spread the load. Any rough terrain performance of scissor lifts is intended only for travelling to the work position.

Facelift (GB) Ltd

**Abseiling**

3.6.22 The use of abseiling, or roped access, allows inspections to be carried out where the provision of more conventional means of access would be difficult or prohibitively expensive. Access is gained from above by means of suspended ropes which provide means of support and positioning. In addition to inspecting vertical faces of a bridge it is also possible to inspect the soffit using ropes or light weight metal structures slung under the bridge.

3.6.23 Abseiling is a specialised task and must only be undertaken by trained and experienced firms. An inspector using this method must have a support team at all times and sufficient, well-maintained equipment.

3.6.24 Due to the nature of the equipment it may not always be possible to inspect all parts of the structure at touching distance. It may be necessary to attach eye bolts and other fixing points on the structure to anchor or support ropes. Further information is provided in *Guidelines on Use of Roped Access Methods for Industrial Purposes* [54].

**Permanently Installed Access**

3.6.25 Some large or unusual bridges have permanently installed access equipment in the form of ladders, walkways, cradles or gantries or provision for such equipment such as gantry rails. Before using any permanently installed access equipment the inspector should ensure that the equipment has been maintained and is safe to use: it should be clear who is responsible for regular inspection and maintenance. Where appropriate, the equipment should be examined and tested before use.

3.6.26 The inspection work should be planned to ensure the design/safe working loads are not exceeded and any other limitations on use are adhered to. Where the safe working load of the equipment is not known this should be determined before use. Only competent and trained operatives should use the equipment.

3.6.27 A mobile gantry including any fixings or runway beams requires its own programme of inspection and maintenance to ensure its safety. Consideration should be given to the requirements of the Institution of Structural Engineers' report on *The Operation and Maintenance of Bridge Access Gantries and Runways* [12]. Hoists, winches and associated cables should be inspected in accordance with the requirements of the relevant orders under the *Factories Act* [13].

**Personal Protective Equipment**

3.6.28 Inspectors should wear personal protective equipment (PPE) to suit the operations being undertaken. Commonly required PPE includes:

- ***Safety helmet*** – *The Construction (Head Protection) Regulations* [55], as amended by The Personal Protective Equipment at Work Regulations [56], require suitable head protection to be provided and worn when there is a risk of head injury. Only Sikhs wearing turbans are exempt. For working at ground level an industrial safety helmet is suitable. However, for working at height, where there is a significant risk of falling a climber's helmet is advisable. A climber's helmet has no peak and is securely attached by adjustable straps.

- ***Eye protection*** – Safety spectacles with toughened lenses and side screens or safety goggles should be worn when drilling or undertaking any process for taking samples of hardened material (e.g. concrete, masonry, metal) for testing or analysis. Eye protection is also needed when using a chipping hammer to remove any material which has become partly detached.

- ***Hearing protection*** – *The Control of Noise at Work Regulations 2005* [57] require that suitable hearing protection such as earmuffs, earplugs, semiinserts/caps, should be provided and worn when carrying out noisy work, e.g. drilling or when entering hearing protection areas. Hearing protection should be worn properly (inspectors should be trained on how to do this), and at all times when undertaking noisy work, and/or when working in hearing protection areas. Further information is contained in the Health and Safety Executive's leaflet *Noise at work* INDG362(rev1) [58] and pocket card *Protect your hearing or lose it!* INDG363(rev1) [59].

- ***Safety footwear*** – Safety boots or shoes with steel toe caps and steel mid-soles should be worn. For working in shallow water or corrosive materials, Wellington boots with steel toe caps and steel mid-soles should be worn. Waders should be used with caution; in the event of falling over in water, the waders may float, inverting the wearer and making it difficult to regain an up-right posture (see paragraphs 3.5.23-3.3.18).

- ***High visibility clothing*** – High visibility outer clothing of approved type should be worn at all times, except while in a vehicle, when working within the highway boundary or on railway property.

- ***Clothing*** – Inspection staff should wear clothing appropriate to the weather conditions, where appropriate, this should include standard industrial overalls.

- ***Gloves*** – It is important to select suitable gloves for the job. In general, gloves of cotton or leather are intended for protection against handling concrete and steel, while rubber or PVC laminated gloves are for protection against chemicals, cement, solvents and glue.

- ***Full body safety harness with lanyard and shock absorber*** – A full body safety harness fitted with an energy absorber, lanyard and connectors should be worn at all times when working where there is a significant risk of falling. All mobile elevating work platforms should be equipped with safety harness attachment points.

- ***Dust mask*** – In dusty conditions or when using equipment which creates dust, appropriate respiratory protective equipment should be worn. In most situations a filtering face mask will suffice. However, in confined spaces or when using certain solvents, other equipment, for example breathing apparatus, may be needed

- ***Buoyancy aid*** – Inspection staff should wear a buoyancy aid when working in or over water or in danger of falling into deep water.

3.6.29 Other specialised equipment will be required in certain situations; for example, breathing apparatus for use in confined spaces. The actual requirements should be specified in the risk assessment.

3.6.30 All PPE should be handled, stored and used carefully. It should be protected and maintained as recommended by the manufacturers. All PPE should be fitted correctly and securely, badly fitted equipment may not perform as anticipated and could even be a hazard in itself.

**Data Recording Equipment**

3.6.31 The method used to capture defect data on site is at the discretion of the Supervising Engineer and will depend on the equipment in use both on site and in the office. Typical methods include:

- Traditional clipboard with waterproof cover and pencil with standard pro forma or pro forma printed specifically for each structure, to record text, measurements and sketches.
- Pocket tape recorder to record the findings.
- A robust data logger or notebook computer, entering the information directly onto screens, which mimic paper pro forma.
- Digital cameras, mobile phone cameras and/or video cameras.

3.6.32 Digital cameras provide an effective means of recording defects and other features of a structure. However, good quality pictures require considerable memory capacity, so an adequate supply of spare memory is essential on site. Most digital cameras enable the picture to be checked immediately to see if it is of suitable quality. Mobile phone cameras may be used to send photographs to the Supervising Engineer for comments while on site.

3.6.33 Video cameras are rarely used in inspection as they generally require a reasonable level of proficiency from the inspector, combined with subsequent editing and referencing. However, video cameras can be useful in particular circumstances such as recording movement or at locations of difficult or expensive access. In this latter scenario a video camera could be mounted on a boom or robot to be sent into areas where human access is expensive, difficult or impossible, although specialist equipment is likely to be required for controlling the camera remotely and for viewing the image.

3.6.34 In order to identify which structure and what part of the structure is being shown, it is essential to provide a means of referencing for all forms of pictorial records, i.e. sketches, photographs, digital pictures and video recordings.

**Measuring Equipment**

3.6.35 Depending on the type of inspection and the data required to be collected, the inspector may also need relevant measuring equipment such as that listed in Table C.7.

## 3.7 STRUCTURE RECORDS

3.7.1 When preparing for inspections, a review of the structure records should be undertaken, to obtain a thorough understanding of the characteristics of the structure and of any features or defects which may require special attention, such as the condition of the structure at the time of the last inspection and any significant maintenance or modifications since the last inspection.

3.7.2 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 CDM Health and Safety File, such as those as defined in *BD 62* [60]. This should contain relevant information associated with the whole life management of the highway structure and include records under the following generic headings:

- Inventory Data
- Drawings
- Design Data
- Construction and Demolition Methods
- Materials, Components and Treatments
- Certification and Test Results
- Operation Requirements
- Inspection Schedules and Records
- Maintenance Records
- Structural Assessment and Load Management Data
- Legal Documentation
- Environmental Information
- Supplementary records

3.7.3 It is desirable that the records listed above, and described in more detail in BD 62 [60], are held for all existing structures as these are extremely useful and may contribute to reducing the work of preparing for inspections. For example, records of the methods of access and traffic management used for previous inspections, together with notes on any problems encountered, will eliminate the need to plan the work from scratch.

3.7.4 For some existing structures there may be gaps between the records listed above and those currently held. The Supervising Engineer should seek to identify these gaps and close them in a cost effective and efficient manner by combining record reviews, data collection and record creation with on-going management activities. For example, these activities may be combined with General Inspections, Principal Inspections and/or routine maintenance activities, when records could be verified by inspectors whilst on site.

3.7.5 Where the structure is old it may be helpful to obtain information concerning the construction materials and methods in use at the time of construction. Several publications [61, 62 and 63] provide useful background information on historical construction procedures for concrete, steel and masonry structures.

## 3.8 TYPE AND EXTENT OF TESTING

3.8.1 Site testing is normally identified during or following a General, Principal or Special inspection or it may be required to obtain additional data to support a structural assessment. It is therefore essential to plan testing operations, i.e. the range of tests and their location, and their extent and intensity, to suit the specific objectives for which testing may be required. Volume 1: Part E of the Manual provides a summary of testing methods relevant to highway structures.

## 3.9 COMPETENCE OF INSPECTION STAFF

3.9.1 As outlined in Volume 1: Part A: Section 4: Paragraph 4.1, 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.

3.10 Notification of Other Owners and Third Parties

3.10.1 Highway authorities do not necessarily own all the land under or near a highway structure and may only retain a right to access. Where inspections require access to land under different ownership, either at the highway structure or adjacent to it, the records should be checked and any landowners and/or tenants consulted to agree arrangements.

3.10.2 For bridges over railways, canals and navigable waterways, it is essential to consult with the relevant authority well in advance and agree details of possessions and safe working practices (see paragraphs 3.5.21-3.5.22 for further advice). For underbridges or culverts over non-navigable watercourses, the appropriate drainage or environmental authority may need notification (local Drainage Board, Environmental Agency etc).

3.10.3 The presence of services in or near the highway structure should be considered and the service authorities consulted for details. Underground services or drains may restrict the placing of access equipment or the location of trial excavations. Overhead lines may also restrict the types of access equipment to be used.

3.10.4 Consultation with environmental or conservation bodies may be necessary where the inspection work is liable to have a significant environmental impact (see paragraph 3.11).

3.10.5 In some circumstances, it may be necessary or advisable to notify the general public of the proposed inspection work. Appropriate situations that should be considered include:

- where severe delays to road users are unavoidable;
- where the inspection work would result in the temporary closure of vehicular or pedestrian routes; or
- when noisy or night-time working is required in residential areas. In such cases the Environmental Health Department of the local authority should be consulted and prior consent obtained.

3.10.6 Prior notification and advance publicity could help reduce distress that may be caused by the work, by informing people of the need and duration of the work and demonstrating that they have been considered.

## 3.11 ENVIRONMENTAL CONSIDERATIONS

3.11.1 Due consideration should be given to the environment when inspections are planned and undertaken at highway structures, including access and working operations at adjacent areas. The Supervising Engineer should ascertain whether any significant environmental impacts are likely to occur and, if so, seek expert advice to identify and implement the appropriate working practices and/or mitigation measures. Details of suitable sources of environmental guidance may be obtained from the organisations listed in Appendix A. Particular attention should be placed on maintaining the population of the country's characteristic fauna and flora and the communities they comprise [64].

3.11.2 Some plant and animal species and their habitats are given special protection by UK and European legislation [65] and a list of specially protected species is provided in Appendix D. Highway structures, although man made, are part of the landscape and quickly become habitats used by wildlife. Also, some structures are situated in areas of special environmental interest or designated areas protected by statue, which could be damaged by inspection activities. The following sections outline the principal environmental aspects, also summarised in Table C.8, which should be considered and include recommendations for planning and carrying out inspections.

**Table C.8 – Environmental Considerations**

| Impacts on | Aspects to be considered | Action | Paragraph |
|---|---|---|---|
| 1. People | | | |
| in vehicles | Safety and disruption of traffic | Provide traffic management | 3.5.4-3.5.15 |
| pedestrians | Safety and convenience | Possible diversionary routes | 3.5.4-3.5.15 |
| | | Fence off works | 3.5.17 |
| nearby residents and businesses | Noisy operations | Adopt quiet methods<br>Avoid night working | 3.11.3-3.11.4 |
| | Night time working | Obtain consent from EHD | 3.10.5-3.10.6 |
| | | Advance publicity | 3.11.3-3.11.4 |
| landowners and tenants | Convenience and access | Check records for right of access and agree access arrangements | 3.10.1 |
| 2. Farmland | | | |
| Livestock | Access, timing, etc | Consult farmer | 3.5.16-3.5.20 |
| | Straying | Fence off works | 3.5.17 |
| | | Close gates etc. | |
| | Disease | Adopt necessary procedures | 3.5.16-3.5.20 |
| Crops | Crop damage | Consider timing of inspection | 3.5.16-3.5.20 |
| | | Keep to arranged locations | |
| | Disease | Adopt necessary procedures | 3.5.16-3.5.20 |

Continued

| **Table C.8 – Environmental Considerations** (continued) | | | |
|---|---|---|---|
| **Impacts on** | **Aspects to be considered** | **Action** | **Paragraph** |
| 3. Habitats | Ecological or landscape significance of adjacent land | Obtain advice/consent from relevant body.<br>Keep to arranged locations | 3.11.22-3.11.24 |
| 4. Watercourses | Pollution | Adopt good practice<br>Avoid spillage of fuel or other pollutants | 3.11.25-3.11.28 |
| 5. Plants | Destruction of rare or protected species | Adopt necessary procedures<br>Keep to arranged locations | 3.11.29-3.11.31<br>3.11.5-3.11.7 |
| 6. Wildlife | | | |
| Bats | Disturbance of bats or roost sites | Consult the SNCO and arrange bat survey where required<br>Time inspection to avoid disturbance | 3.11.29-3.11.31<br>3.11.8-3.11.12 |
| Nesting birds | Disturbance of birds when nesting | Time inspection to avoid disturbance | 3.11.14-3.11.17<br>3.11.29-3.11.31 |
| Other wildlife | Disturbance of otters or other protected wildlife | Obtain general licence to remove pest species<br>Consult relevant organisations | 3.11.29-3.11.31<br>3.11.18-3.11.21 |
| Bird droppings | Accumulations can be a health hazard | Use respirators and other PPE | 3.3.9-3.3.17 |

**People**

3.11.3 Some highway structures are sited in sensitive areas, such as residential areas or adjacent to hospitals, where inspection work or noise from plant may cause inconvenience or nuisance to the public. The adoption of good working practices and sensible timing may help to reduce the effects of noise. Nevertheless the environmental health department of the local authority should be consulted if there are likely to be problems. The environmental health officer may set limits to the noise which will be permitted.

3.11.4 Night-time working can be particularly disruptive. If work at night is planned near residential properties or other sensitive areas, the environmental health department must be consulted and prior consent obtained. This consent will stipulate noise limits.

**Plants**

3.11.5 There is currently approximately 39,000 plant or plant-like species, including algae, fungi, mosses, liverworts, ferns, horsetails, and flowering plants (trees and shrubs), native or naturalised in the UK. Plants, and the diversity of plants in a particular area, reflect the influence of many interrelated factors such as soil, hydrology, climate and type of management (either natural or by humans). Some species have very specific requirements, while others have adapted to almost any situation.

3.11.6 Plants can be found in almost any habitat, wherever sufficient resources can support their requirements. Some plant species have evolved very complex life cycles or behaviour based on an interaction with other species. Plants form the basic material on which most other species survive.

3.11.7 Some plant or plant-like species are protected under the *Wildlife and Countryside Act* [66] and the Conservation (Natural Habitats, etc.) Regulations [67, 68]. Under Section 13 of the *Wildlife and Countryside Act* [66], it is an offence to intentionally pick, uproot, or destroy any wild plant. The general procedure to be followed for the consideration of protected species during inspections is outlined in paragraphs 3.11.29-3.11.31. Further guidance for avoiding the destruction of protected or rare plants is contained in *HA 84* [65] and the *Ecology and Nature Conservation Advice Note* [64].

**Bats**

3.11.8 Bats in Britain and Ireland have declined in numbers due to habitat degradation, widespread use of pesticides, persecution, and destruction of their roosting sites. The roosts are of great importance to their survival. Due to the decline and numerous threats they face, bats and their roosts are legally protected in the United Kingdom under the *Wildlife and Countryside Act* [66], the *Conservation (Natural Habitats, etc.) Regulations* [67, 68] and the *Wildlife (Northern Ireland) Order* [69].

3.11.9 Under the above legislation, it is an offence to deliberately capture, injure or kill a bat, and to possess or control any live or dead bat. Most important so far as bats and highway structures are concerned, the legislation affords protection to any structure or place the bat uses for shelter, protection or breeding, by making it an offence to damage, destroy or obstruct access to such a place, as well as to deliberately disturb the bats whilst they are using it.

3.11.10 A wide range of bridge types have suitable crevices for bats, offering safety, cool and stable temperature conditions, high humidity, and nearby drinking water and feeding areas for bats roosting in spring, summer and autumn. Bridges in river valleys are especially liable to be used as bat roosts. Some studies have indicated that up to 16% of bridges in England and Wales are used as bat roosting sites. Stone bridges are more likely to provide suitable crevices than concrete or steel structures. However, a survey in Cumbria indicated that 25% of concrete bridges had suitable roost crevices and 5% had bat roosts [70].

3.11.11 Bats may be found in bridges at any time, and may use different parts of the same bridge depending on the time of year, as they require different roost conditions with the changing seasons, i.e. bats often move between summer roosts, hibernacula and transition roosts. Nursery roosts where the females give birth and rear their young (approximately June to August) would be found in warm sites. Bridges with deep crevices may offer good hibernation sites (approximately October to March) when isolated from external temperature fluctuations and have stable, cool temperatures. Partially blocked arches are particularly suitable as hibernacula. Male roosts and transition roosts tend to be more variable in nature. Many bridges contain suitable crevices which could be used as night roosts for resting, eating large prey, or socialising.

3.11.12 Most roosts are located in bridge superstructures, but roosts have also been found in abutments, spandrel walls and parapets. Bats can roost in almost any type of crevice that is greater than 100mm deep, 12mm wide and protected from the elements. The wide variety of crevice types that have been used include:

- Crevices between stones where mortar has fallen out, or in damaged stonework;
- Drainage holes and pipes, including ceramic and steel pipes;
- Expansion joints;
- Construction joints;
- Gaps between beams and slabs in bridge decks;
- Gaps created where the span overlies the piers or abutments;
- Box voids in concrete structures; and
- Behind thick growths of ivy on bridges.

3.11.13 A guide for signs of bats is given in Appendix E. The general procedure to be followed for the consideration of protected species during inspections is outlined in paragraphs 3.11.29-3.11.31. Further guidance on avoiding the disturbance of bats or their roosts in bridges is provided in *HA 80* [71].

**Birds**

3.11.14 Birds often nest in bridge structures and several species use bridges as night-time roosts. Some ground nesting birds may nest on the ground near or adjacent bridge structures. All birds, their nests and eggs are protected under the *Wildlife and Countryside Act* [66] and the *Wildlife (Northern Ireland) Order* [69]. Under this legislation, it is an offence, with certain exceptions, to intentionally:

- kill, injure or take any wild bird;
- take, damage or destroy the nest of any wild bird while it is in use or being built;
- take or destroy the egg of a wild bird; or
- disturb any wild bird listed in Schedule 1 of the *Wildlife and Countryside Act* [66] (see Appendix D) while it is nest building, or at a nest containing eggs or young, or disturb the dependent young of such a bird.

3.11.15 The most notable exceptions to the above provisions are:

- An authorised person (e.g. a landowner or occupier) may kill or take “pest species” (see Table C.9) and destroy or take the nest eggs of such a bird. This is permissible under the terms of general licences issued by Government departments.

- A person charged with killing or attempting to kill a wild bird, other than one included in Schedule 1 of the *Wildlife and Countryside Act* [66] (see Appendix D), is not guilty of an offence if they can demonstrate that this action was necessary to preserve public health or air safety, prevent spread of disease, or prevent serious damage to agriculture.

| **Table C.9 – "Pest Species" of Birds** |
|---|
| Carrion crow |
| Collared dove (not in Northern Ireland) |
| Feral pigeon |
| Great black-backed gull |
| Herring gull |
| House sparrow |
| Jackdaw |
| Jay (not in Northern Ireland) |
| Lesser black-backed gull |
| Magpie |
| Rook |
| Starling |
| Wood pigeon |

3.11.16 Game birds are covered by separate Game Acts, which generally provide protection during the close season. Close seasons vary, but normally run from the beginning of February to the end of August.

3.11.17 The general procedures to be followed to avoid illegal disturbance of birds or their nests are outlined in paragraphs 3.11.29-3.11.31. It should be noted that accumulations of bird droppings at roost or nest sites can be a health hazard; appropriate precautions should be taken (see paragraphs 3.3.14-3.3.17, 3.4 and the *RSSM* [25]).

**Other Wildlife**

3.11.18 Bridges or their immediate surroundings may be inhabited or frequented by other protected wildlife. Where the presence of protected wildlife is known or suspected, the Supervising Engineer should contact the Statutory Nature Conservation Organisation (SNCO) or county or regional wildlife trust to seek advice on mitigating any disturbance. Details of suitable sources of environmental guidance may be obtained from the organisations listed in Appendix A.

3.11.19 As an example, bridges or culverts over watercourses may be frequented by otters. Their presence can sometimes be detected from droppings (spraints) left to mark their territory on ledges, rocks or sediment under bridges. Hollows in bridge abutments or culverts and drains may be used as lying-up sites or holts. The adjacent riverbank may also be used. Otters and their holts are also protected under the *Wildlife and Countryside Act* [66], the *Conservation (Natural Habitats, etc.) Regulations* [67, 68] and the *Wildlife (Northern Ireland) Order* [69]. The Supervising Engineer should contact the SNCO or county or regional wildlife trust to ascertain whether otters are likely to be present at specific bridges. This information should be updated every few years since the range of otters is increasing in some parts of the country. Further information concerning otters is provided in *HA 81* [72].

3.11.20 Water voles may also be found along certain watercourses. Although it is unlikely that they may be found within a structure their burrows may be located nearby. At the time of publication of this Manual water voles themselves were not protected by law (it is anticipated that this may change in future), however, limited legal protection through Schedule 5 of the *Wildlife and Countryside Act* [66] (as amended) in respect of Section 9(4) is given to their habitats. It is an offence to intentionally damage, destroy, or obstruct access to any structure or place which water voles use for shelter or protection or disturb water voles while they are using such a place.

3.11.21 Badgers are known, if the ground conditions are right, to burrow next to structures especially within embankments found near or adjacent to bridges. They as well as their habitat are protected under the *Badgers Act* [73] and one requires a licence to remove them or close their setts. Further information concerning badgers is provided in *HA 59* [74].

**Surrounding Habitats**

3.11.22 The land at and adjacent to the structure, or along the route used to gain access to the structure, may be a designated site [64], i.e. areas of high nature conservation value protected to varying degrees by statute, international conventions, or local authority planning controls. They form a network of habitats which may be of global, international, European, national, regional or local importance. Generally, the priority for protection of designated sites is as follows:

- Sites of international importance:
- World heritage sites;
- Biosphere reserves;
- Ramsar Sites – wetlands of international importance;
- Special Protection Areas (SPA);
- Special Areas of Conservation (SAC)
- Sites of national importance:
- National Nature Reserves (NNR);
- Marine Nature Reserves (MNR);
- Sites of Special Scientific Interest (SSSI);
- Areas of Special Scientific Interest (ASSI);
- Areas of Special Protection for Birds (AOSP);
- Ancient Woodlands;

- Natural Heritage Areas
- National Parks;
- Areas of Outstanding Natural Beauty (AONB);
- Environmentally Sensitive Areas (ESA);
- Sites of Regional or Local importance:
- Local Nature Reserves (LNR);
- Regional Parks;
- Non-Statutory Sites of Importance for Nature Conservation;
- Non-Statutory Nature Reserves
- Forest Nature Reserves
- County Sites of Biological Interest;
- Other wildlife sites

3.11.23 In any of these areas there may be advisory or statutory restrictions on intended activities of the bridge inspection team. It will therefore be necessary to contact the SNCO or the county or regional wildlife trust or biological records office (see Appendix A) to establish whether there are any areas of significance at or near the structure. Should there be, the methods of working should be drawn up taking this into account.

3.11.24 Access to the structure should be arranged so as to minimise damage to the environment. Vehicles and equipment can cause rutting or ground compaction as well as direct damage to the vegetation. The impact can be minimised by careful routeing of vehicles, by the use of temporary access ways or mats, or by the timing of the work. Wherever practicable, vehicles should be confined to existing tracks or hardstandings.

**Pollution**

3.11.25 Care should be taken to avoid pollution. This is most likely to occur from fuel spillage or from effluent such as the lubricating water used during core drilling. The pollution of controlled waters is covered by the *Water Resources Act* [75], the *Control of Pollution Act* [76] and the *Water (Northern Ireland) Act* [77] and it is an offence to cause or knowingly permit any poisonous, noxious or polluting matter or any solid waste to enter controlled waters. Controlled waters are all watercourses (i.e. both surface and ground water).

3.11.26 Drip trays should always be used under petrol or diesel powered plant where there is any chance of polluting controlled waters. Oil powered pumps, generators and the like should be positioned on impervious drip trays surrounded by earth or sand bunds and located at least 10 metres from any controlled waters.

3.11.27 Some testing operations can give rise to other forms of pollution, such as dust. This can normally be avoided or minimised by the use of best practice procedures. In some sensitive areas noise can cause a nuisance, but good practice and sensible timing should alleviate the problem.

3.11.28 In the *national Air Quality Strategy* [78] eight substances were identified as requiring closer control due to their effects on people and the environment. As a result, some authorities have designated Air Quality Management Areas (AQMA) located around major roads, and have produced or are in the process of producing action plans identifying how the air quality issues in these areas could be controlled or tackled. Inspection personnel should be aware of AQMAs and have a duty to ensure the air quality within these areas is not adversely influenced by any operations undertaken as part of the inspection.

**Consideration of protected species during inspections**

3.11.29 Due consideration should be given to protected species during inspection planning. Inspections should be divided into two classifications to identify those inspections that are likely and unlikely to impact on protected species. Two classifications that may be used are:

- Non-invasive inspections – non-invasive inspections are essentially those requiring no, or limited, physical contact with the structure, e.g. a bridge is inspected visually, either from the ground level, the deck or from permanently installed access equipment. Safety and General Inspections are of this type. Non-invasive bridge inspections may be undertaken at any time, subject to the constraints of access.

- Invasive inspections – invasive bridge inspections are those requiring in-situ testing and the use of hand, probe or torch to investigate deep (i.e. greater than 100mm) crevices. Potential types of crevice are listed in paragraphs 3.11.8-3.11.15. Some Principal and most Special Inspections are ‘invasive’.

3.11.30 When undertaking a *non-invasive* inspection it may be beneficial for the inspector to be aware of protected species before a undertaking a (non-invasive) General Inspection, therefore if evidence of different protected species are found during the inspection this should be reported to the Statutory Nature Conservation Organisation (SNCO), but the inspection may proceed, see Figure C.6. Figure C.6 also presents a procedure that may be followed for *invasive* inspections, key points of which include:

- The structure records should be checked to ascertain whether or not protected species are associated with the structure and if there is a need for any special measures related to the protected species.

- If the structure is a known protected wildlife or other species site, the SNCO and any other relevant organisations (see Appendix A) should be able to provide information and advice on when, and possibly how, work should proceed. In general, work may be undertaken at specific times of the year depending on, for example, how or when wildlife uses the structure, see Table C.10.

- If the structure is not a known protected species site, the inspection may proceed. However, if the structure has potential for the presence of protected species then a pre-inspection survey by a competent environmental specialist should be arranged. This would prevent any delays to the work if protected species were found.

- During the inspection, if any evidence of protected species is found it should be reported to the SNCO, but the inspection may proceed.
- During the inspection if protected species are found, then ‘invasive’ work should stop and the SNCO contacted. The SNCO should make provision for a visit by a competent environmental specialist and then advise on how the work should proceed.

3.11.31 If a structure is used all year by wildlife, it is unlikely that the same part of the structure will be used all year round. Where this is the case, inspection could proceed on the parts of the structure not currently occupied. However, appropriate advice relevant to the specific situation should be sought.

3.11.32 Any accidental spillages of hydrocarbons or other pollutant into a watercourse should be reported immediately to the Environment Agency, or other appropriate organisation, using the emergency hotline (see Appendix A).

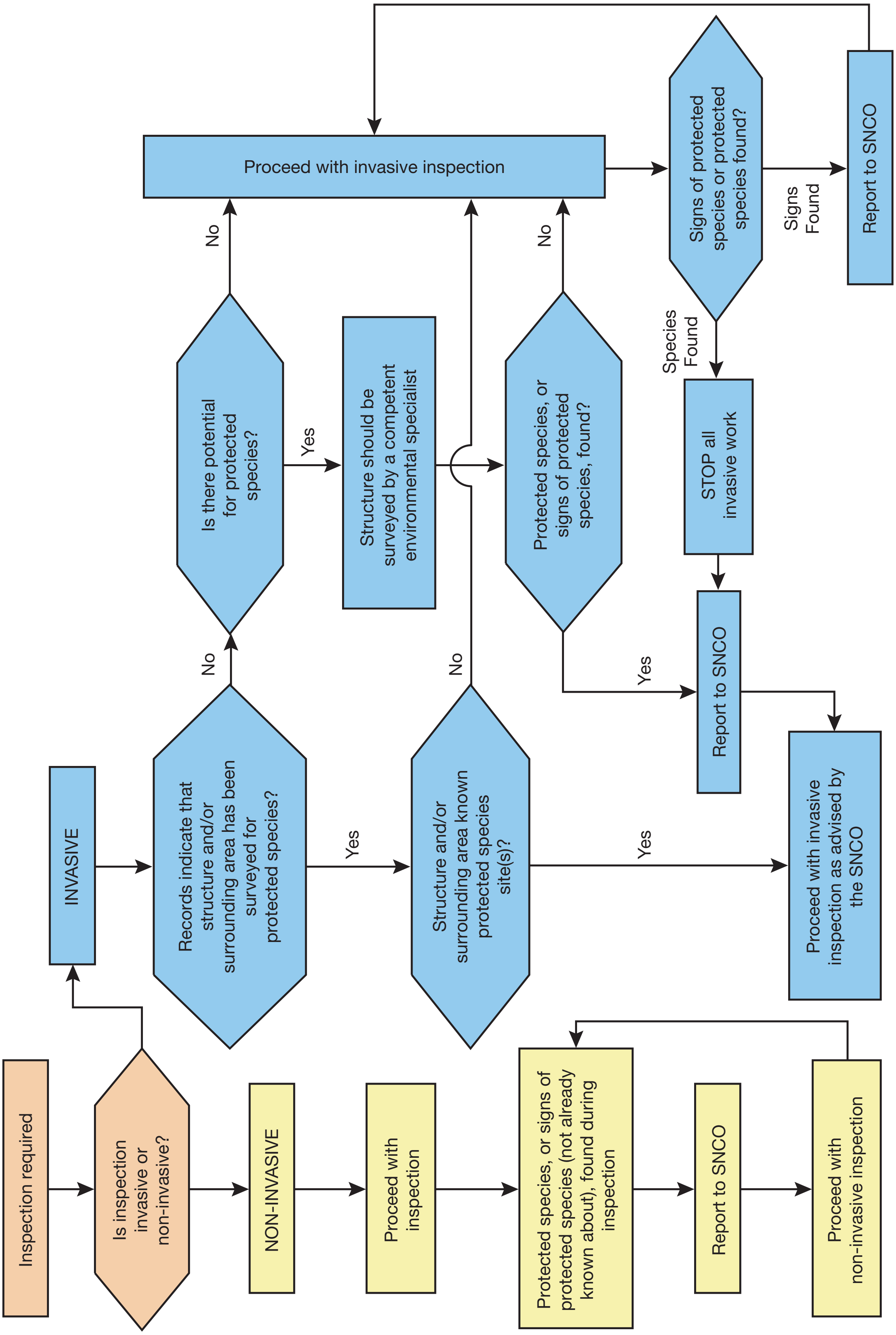


**Figure C.6 – Procedure for consideration of protected species at highway structures**

| **Table C.10 – Seasonal Constraints: Animals** | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Month** | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
| Birds | Breeding | | | | Start of nesting dependent on local variations | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| | Over wintering | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Amphibians | Breeding | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| | Hibernation | ■ | ■ | ■ | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ |
| Reptiles | Breeding | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| | Hibernation | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ |
| Invertibrates | Breeding | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| | Over wintering | Egg stages | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | Egg stages | ■ | ■ | ■ | ■ | ■ |
| Bats | Breeding | | | | | | Breeding | ■ | ■ | ■ | ■ | ■ | ■ | Nursery roosts | ■ | ■ | ■ | ■ | ■ | ■ | | | | | |
| | Over wintering | Hibernacula | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | Hibernacula | ■ | ■ | ■ |
| Badgers | Breeding | Females in setts with young | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | ■ |
| Otters | Breeding | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Dormice *(Muscardinus avellanarius)* | Breeding | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| | Hibernation | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| Fish | Adult sea trout | | | | | | | | | | | Ascend rivers to spawn | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| | Adult salmon | ■ | ■ | ■ | ■ | | | | | | | | | | | | | Spawning | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Salmon smolts | | | | | Migration to sea | ■ | ■ | ■ | ■ | ■ | | | | | | | | | In river bed | ■ | ■ | ■ | ■ | ■ |
| | Salmon eggs or fry | | | | | | | | | | | | | | | | | | | | | | | | |
| | Coarse fish | | | | | | Spawning | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | |

**Notes**

1. The bars indicate the main periods to avoid when undertaking works which affect these species. Consideration should be given to climatic and geographical variations, which may bring forward or delay the period.
2. Some animals and their habitats have statutory protection. Where protection is given by legislation advice should be obtained from the relevant Statutory Consultees.
3. Badgers should not be disturbed between 1 December and 30 June as females are in setts with young.
4. In respect of fish, the constraints indicated provide a guide only and variations due to species and season should be considered on a site-by-site basis.

# Section 4
# Performing Inspections

## 4.1 INTRODUCTION

4.1.1 Upon arrival on site, a careful check should be carried out to confirm the identity of the structure, i.e. to ensure it is the correct one. Mistakes can easily occur and in some instances records may be misleading. Unless the inspection team is already familiar with the structure, a quick look around is advisable to make sure that elements such as movement joints, bearings, etc. may be correctly identified, that the orientation is understood by the team and that any drawings confirm the observed layout. Where possible the co-ordinates of the structure should be checked.

4.1.2 Inspectors should be aware that the appearance of some structural materials may sometimes be misleading. For example, a retaining wall with a masonry face may be solid masonry or it may be masonry cladding to some other material such as mass concrete, reinforced concrete, steel sheet piling or even reinforced earth. Similarly 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. In the majority of cases the structure records should contain sufficient information to clarify such situations; however, inspectors should be aware that some details may have not been recorded or that the structure records are in the process of being up-dated.

4.1.3 Before commencing work, inspectors must ensure that any necessary traffic management measures (see paragraphs 3.5.5-3.5.20) are in place, that they have been correctly set up and that they are diverting the traffic in a safe manner. At intervals during the work, checks should be made to ensure that the traffic management is still operating correctly, for example signs may have fallen over or become obscured; cones may have been displaced; signals may have ceased to function, etc. Traffic management is put in place for the safety of the inspectors as well as that of the public and as such inspectors have a duty of care to ensure that it operates satisfactorily.

4.1.4 The inspection should proceed in a logical and systematic manner within the constraints imposed by any safety, traffic management and access considerations. The first stage of any inspection should be to review the overall condition of the structure paying particular attention to any evidence of structural movement, e.g. settlement. During this initial “overview” of the structure, the inspector should focus on identifying the effects of structural defects and not the defects themselves.

4.1.5 Inspections should be thorough, i.e. conscientious and to the full requirements of the specific brief for the type of inspection being undertaken. The work should never be skimped and if problems are encountered, these should be discussed with the inspection team leader and, if necessary, referred to the Supervising Engineer. For example, a typical problem might be difficulty in obtaining access to some part or parts of the structure. Every effort should be made, without compromising safety, to obtain all the required information during the inspection. Where there are restrictions on the working hours, such as on busy motorways or during railway track possessions, it is particularly important to work efficiently so that the work may be completed within the allotted time.

4.1.6 In some instances, the lead inspector may be required to consider whether the value of the inspection would improve by undertaking work additional to the original brief while on site. For example, the results of early tests or the initial discovery of unforeseen movements should be used to review the scope of the work. Any proposed changes should be agreed with the Supervising Engineer prior to being implemented.

4.1.7 Inspectors should always be alert to anything unusual while on site and focus on any part of the structure that may cause particular concern. Possible examples include incomplete or missing secondary elements, clearances that are too small or too large, or elements which are over or under-sized. Any such observations or concerns should be brought to the attention of the Supervising Engineer.

4.1.8 Any damage or disturbance caused on or adjacent to a highway structure during an inspection should be made good. This frequently includes reinstating drill or core holes in concrete or masonry, painting exposed steel surfaces or refilling trial pits. The correct materials and good workmanship are essential as poor repairs may result in accelerated deterioration or affect the appearance of the structure.

4.1.9 On completing an inspection, the team should verify that all the information required has been captured. The site must be cleared thoroughly of all equipment, materials and rubbish. If working on a highway, before a stretch of the highway is reopened to traffic, the lead inspector, or another responsible person, should ensure that the area is safe for public use. On railways, a formal checking and reporting procedure should be followed to ensure safety at the end of a possession.

4.1.10 The following sections give general advice and guidance on carrying out inspections for structures constructed of different materials and certain special structures. Detailed advice on the defects that may occur on these structures is included in Part D of the Manual. The level of activity and information acquired should be commensurate with the type of inspection being undertaken.

## 4.2 CONCRETE STRUCTURES

4.2.1 The main cause of deterioration of reinforced concrete structures is corrosion of the reinforcement. Inspectors should pay particular attention to the presence of reinforcement corrosion or the risk that corrosion may occur in the future. Areas particularly at risk are those subjected to leakage of de-icing salts through joints, and concrete subjected to salt spray from passing traffic or from the sea for structures in a marine environment. Vulnerable areas on bridges may include bearing shelves, half joints, piers and abutments, crossheads, ballast walls, deck ends and areas around defective or blocked drainage.


Highways Agency

4.2.2 Where cracking of concrete due to reinforcement corrosion or corrosion of prestressing tendons is suspected, in addition to visual examination it may be appropriate to carry out some simple testing during a Special Inspection such as measurement of chloride content, carbonation depth, reinforcement cover or electrode-potential (half-cell), details of theses techniques are provided in Part E. This would enable a better assessment of the condition of the reinforced concrete and to be made. The results obtained should be recorded in the Structure Records for future reference. Further guidance may be obtained from *BA 35* [5], *BA 88* [79], *Diagnosis of Deterioration in Concrete* [80] and T*echnical Guide 2: Guide to Testing and Monitoring the Durability of Concrete [*81].

4.2.3 Concrete structures suspected of suffering from alkali-silica reaction (ASR) or any other form of chemical degradation should have a Special Inspection to check the cause and extent of any deterioration. Further information on ASR can be found in Structural effects of alkali-silica reaction: technical guidance on appraisal of existing structures [82].

4.2.4 Prestressed concrete structures (pretensioned or post-tensioned) can suffer from any of the defects described above for reinforced concrete. However, particular attention should be paid to cracks in the concrete or any other indication, e.g. rust staining, that the prestressed elements may be subject to corrosion and therefore at risk of loss of prestress.

4.2.5 Post-tensioned concrete bridges with grouted tendon ducts are particularly vulnerable to corrosion and severe deterioration in segmental construction and/or where internal grouting of the ducts is incomplete. Such bridges may have been subjected to a Special Inspection in accordance with *BA 50* [6]. The findings of the Special Inspection should be taken into account when planning and undertaking an inspection. Where such an inspection has not been undertaken previously, a Special Inspection should be carried out. The purpose is to establish whether there are voids in the grouted ducts and the extent of any tendon corrosion or other deterioration, so that the vulnerability of the bridge and its residual strength may be assessed. It is important to determine the form of the bridge and its load-carrying system as this can have a considerable influence on its vulnerability to tendon corrosion.

## 4.3 STEEL STRUCTURES

4.3.1 Steel is particularly vulnerable to corrosion when exposed to wet conditions or to aggressive ions, such as chlorides from de-icing salt, or when exposed to a marine environment. Most steelwork on highway structures is therefore protected with paint or some other protective coating. Corrosion is usually associated with the breakdown of protective systems, which is probably the most common defect associated with steel superstructures. It is important to assess the magnitude, location and form of corrosion and, if possible, identify its cause. Inspectors should assess and record any loss of structural section. Special Inspections of the protective system using specialist inspectors may be required to identify the cause of any deterioration of the paint system and to identify the need for maintenance painting. There are also circumstances when Special Inspections are required in order to identify if corrosion is taking place and to monitor it over a period of time.

Highways Agency

4.3.2 The steelwork in some structures, particularly bridges, has been enclosed to reduce the rate of corrosion and to provide access for inspection. Such enclosures should be inspected during all General and Principal Inspections of the structure. Although enclosures should have long service lives some components or seals may have shorter lives. Further guidance on enclosures for bridges is contained in *BA 67* [83].

4.3.3 Older bridges may be at risk of fatigue-induced failures, although fatigue susceptible details may also be present on more recent bridges. Deformation or distortion of members may reduce the load carrying capacity of the structure. Sighting along flanges may aid checking of members, taking measurement of the maximum deformation if necessary.

4.3.4 Weathering steel is particularly vulnerable in wet/dry situations and at web flange joints, where settled rust deposits may retain water like a sponge. Weathering steel should be visually inspected for irregularities in the appearance of the patina, at critical areas and in particular at fixed joints and expansion joints. Any irregularity of appearance should be reported. Where irregularity occurs, a Special Inspection may be needed to ascertain the cause. Steel thickness measurements on weathering steel are also required generally at six year intervals at predetermined locations to check for loss of steel, normally at the time of a Principal Inspection. Where structures contain such material, the authority should follow the procedures given in *BD 7* [9].

4.3.5 Steel/concrete composite bridges rely on interaction between the steel and the concrete provided by shear connectors. Failure may be indicated by separation between the top flange and the concrete slab. The inspector should examine this interface for evidence of separation.

4.3.6 Corrugated steel buried structures (CSBS) used as culverts, deteriorate mainly through hydraulic wear in the invert and along the wet/dry line. The hydraulic action removes protective coatings and exposes the steel substrate to corrosion. Deterioration of CSBS is also caused by exposure to water laden with de-icing salts or sulphur compounds present in the backfill and surrounding soil. Deterioration of CSBS used as cattle creeps, pedestrian underpasses, etc. will also occur due to this cause. Deterioration is often localised and in extreme cases results in perforation of the steel shell, which might require strengthening works or, if in an advanced state, replacement of the structure. Inspection of corrugated steel buried structures is generally limited to exposed surfaces. Inspectors should look for signs of bulging and deformation in the shape or line of the steel arch or ring and for signs of the settlement of fill in areas above or adjacent to the arch. An overview of the immediate surrounds should be made to identify changes such as erection of structures, subsequent to the construction of the corrugated structure that may, for example, alter the loading or the level of the water table in the vicinity. Further advice on the inspection of these structures is given in *BA 87* [84].

4.3.7 Connections are points of weakness in steel construction, whether welded, riveted or bolted, may have material or loading defects. Inspectors should be aware that structural movement or failure may initially propagate as movement at connections. Therefore, all connections should be checked for defects. Welds, particularly those between deck plates, and stiffeners should be inspected for cracking, which may require the use of non-destructive testing techniques. Bolts and rivets should be checked to establish that none are loose or missing.

4.3.8 Older structures often have details which are susceptible to corrosion so inspectors should give particular attention to areas such as:

- Small gaps between components which are not adequately sealed.
- Where components are built into concrete or masonry.
- Water traps and areas where debris can build up.
- The inside of unsealed hollow members which is not readily accessible, e.g. look for external indications of corrosion and/or use specialist techniques during a Special Inspection.
- Areas subject to leakage of de-icing salts, e.g. members below deck joints, joints in trough or plate decking.

## 4.4 CABLE SUPPORTED STRUCTURES

4.4.1 Particular factors that may affect the performance of cable supported structures include excessive vibrations, corrosion, fatigue, and the general inability to reliably ascertain the condition of the cables, especially in the critical anchorage zones. Depending on the type of inspection performed, currently available methods that may be used for cable supported structures include conventional visual inspections and some non-destructive testing techniques such as magnetic, ultrasonic, x-ray, laser, acoustic, and remote or contact-based vibration methods.

Warwickshire CC

4.4.2 During Principal Inspections of cables, the entire surface of the cable should be inspected at close range, followed by an inspection of neoprene boots and rings, visible surfaces of guide pipes, and accessible anchorage surfaces. Visual inspections of cables typically involve the following (the relevance of the following will depend on the specific arrangement of the cables and the size of the structure):

- Identification of longitudinal or transverse cracking or excessive bulging in the sheathing, as well as damage at connections to dampers or cross cables.
- Inspection for cable alignment irregularities including waviness or excessive sag. Cable sag may be estimated or measured using optical devices or through video or photo image processing. Cable angle may be measured with an inclinometer at specific points.
- Identification of changes to bridge deck elevations.
- Examination of protective tape wrapping, e.g. tears, cracks, and delaminations.
- Examination of the sheathing, particularly any evidence of cracking in the sheathing located at high stress areas.
- Identification of damage to connections between anchorage pipes and cable sheathing.
- Inspection for damage, loosening, lack of water tightness, and deterioration of neoprene boots and band clamps.
- Inspection for damage or dislocation of neoprene rings and keeper rings, if applicable.
- Identification of gaps between the neoprene rings and the sheathing.
- Examination of sheathing surface inside the guide pipe through a boroscope or other means, looking for damage or deformation to the sheathing near the anchorage.
- Identification of cracking or damage to guide pipes or evidence of the impact of cable components on guide pipes.

- Examination of surface conditions on the visible anchorage components including ring nuts, end caps, and bearing plates.
- Examination of visible parts of saddles for damage, corrosion, and cracking.
- Review of evidence of moisture or fillers (such as grease) exiting the anchorage components. If there is an access port at the end cap (ideally at the lowest point), it can be opened and examined for moisture or moisture contaminated grease.
- Removal, in some cases, of the end caps on the sockets to allow for visual inspection of the anchorage plate and anchorage devices and to see if there is moisture or corrosion inside.
- Inspection of the cross tie cables for sagging, i.e. losing their tension force and require to be retensioned.
- Inspection of damage or cracking on components of cross tie cables. Evidence of fretting and fatigue, especially at connections, are of particular interest.
- Examination of dampers, if any, as per recommendations of manufacturer.

4.4.3 Due to the nature of these bridges and because no two cable supported structures are identical, it is recommended that inspection procedures for major cable supported bridges are tailored to each specific structure. Special Inspections entailing the use of non-destructive methods should be led by a specialist familiar with both the testing techniques and these particular types of structures. Further guidance for the use and effectiveness of appropriate testing methods for cable supported structures are contained in *Synthesis 353: Inspection and Maintenance of Bridge Stay Cable Systems* [85].

## 4.5 MASONRY STRUCTURES

4.5.1 Inspection of masonry structures relies on visual inspection rather than testing. The main defects found on masonry structures are: cracking, arch ring separation, bulging and deformation, loss of mortar, loss of bricks or stones, seepage of water through the structure and deterioration of the bricks or stones. Cracking arises from a variety of causes including overloading, vibration or impact from traffic, settlement, foundation failure, temperature and humidity changes i.e. cycles of freeze/thaw activity or wetting and drying. It may be necessary to initiate a Special Inspection in order to determine the cause of the cracking.

Cambridgeshire CC

4.5.2 Cracks in masonry may affect the appearance only or be indicative of a more serious defect. Recent or progressive cracks are more serious than those which may have occurred soon after the structure was constructed. Evidence that cracks are recent may include clean faces to the crack and loose fragments of masonry or mortar. Cracks formed in the mortar only may be indicative of joint deficiencies. Inspectors should map the extent of cracking in order that comparisons can be made with previous inspections.

4.5.3 Inspections should generally seek to take into account the age of the structure, the type of masonry, local knowledge (many masonry structures are very old) and the exposure environment. Some types of masonry (e.g. sandstone) deteriorate more readily than others (e.g. granite) and this can be exacerbated by the severity of the environment they are in. Further information on the inspection of masonry arches is given in *Masonry Arch Bridges: Condition, Appraisal and Remedial Treatment* [86].

## 4.6 CAST IRON AND WROUGHT IRON STRUCTURES

4.6.1 Cast iron may be found in older bridges, being first used in the United Kingdom in 1779 at Ironbridge. It has only rarely been used since 1914. There are several types of cast iron, the type usually found in structures is known as grey, or flake graphite cast iron, from the dull grey appearance of a freshly fractured surface.

Surrey CC

4.6.2 Wrought iron may be found in older bridges, being first used in the United Kingdom in 1840 and rarely after 1914. The manufacturing processes placed practical limitations on the size of elements so larger elements had to be built up from relatively small components, using wrought iron rivets and bolts.

Wrought iron was also commonly used for cables and forged links, especially in 19th century suspension bridges. Other applications include trusses and lattices, handrails and balustrades.

4.6.3 The homogeneity and purity of cast iron and wrought iron in the aforementioned structures is below the standards of present day materials. This variability should be taken into account in the inspection process. The only certain method for distinguishing between wrought iron, cast iron and steel is chemical analysis and/or metallographic examination of a sample sawn (not flame cut) from the member. However, there are a number of other characteristics of wrought iron elements which give indications of the type of material, and some of these are listed in Appendix F and described in the *Appraisal of Existing Iron and Steel Structures* [87].

4.6.4 Corrosion of both cast iron and wrought iron is relatively slow but it may reach significant proportions particularly for wrought iron because of the age of the structure and the composition of wrought iron. In general, the corrosion products cause expansion and can be readily detected. Corrosion occurs along lines of slag inclusions, which run parallel to the longitudinal axis of the element and causes the material to delaminate. Since this occurs within the element, deterioration of the element may be greater than is apparent at the surface. Tapping with a hammer by an experienced inspector can provide useful qualitative information.

4.6.5 Areas of severe corrosion, graphitisation of cast iron or delamination of wrought iron, identified during a Principal Inspection may need a more detailed Special Inspection to establish the severity of the defect and identify its cause. Where there is a build-up of rust, a visual inspection is not sufficient to evaluate section loss. A Special Inspection is normally needed which includes the removal of rust to base metal and the measurement of section thickness using callipers, ultrasonic thickness meters (for cast iron) or other appropriate methods. Ultrasonic thickness meters are not recommended for wrought iron as they are unreliable due to the laminar nature of the material.

## 4.7 ADVANCED COMPOSITES STRUCTURES

4.7.1 The surface of advanced composites should be inspected for signs of crazing, cracking or delamination and for signs of local damage such as impact or abrasion. Where there is a protective layer, it should be checked to ensure that it is intact. Bonded plates should be checked to ensure that they are not becoming detached. It is recommended that this should generally be carried out by inspectors with experience of the delamination of such materials. Further guidance is given in *Strengthening Concrete Structures with Fibre Composite Materials: Acceptance, Inspection and Monitoring* [8] and *Repair and Maintenance of FRP Structures* [88].

## 4.8 TIMBER STRUCTURES

4.8.1 The main problems for timber structures/elements are decay, insect attack, splitting and separation of laminated layers. The principal forms of decay are dry rot and wet rot with the latter more likely on highway structures. Timber attacked by dry rot looks dry and brittle, developing deep cracks across the grain and breaking into brick-shaped pieces. Wet rot can only attack wood with high moisture content; it does not spread into dry wood. Affected wood becomes soft, pulpy and wet, with the structure of the wood progressively breaking down. Prolonged dampness and vegetation growing from crevices are also signs that the timber may be decaying. Areas which are particularly susceptible to decay are those which are in contact with both water and air.

4.8.2 Chemical treatment to prevent decay will not penetrate to the middle of the timber so even if the outside is sound, decay may still be occurring below the surface. Signs of hidden decay include water stains on the timber or soft areas on the surface.

4.8.3 Insect attack may occur anywhere and can seriously weaken a timber structure. Insect holes usually have dust in them or near them. A few small holes (less than 5mm in diameter) are not usually serious. If there are more small holes or many larger holes, the problem is serious.

4.8.4 Evidence of possible decay or insect attack can be detected using a sharp instrument to check the condition below the surface. Where deterioration has occurred samples may be taken for examination and testing. Sampling in this way is usually only done in exceptional circumstances.

4.8.5 Splitting commonly occurs in timber as it dries out, and does not necessarily seriously affect the structure. Splitting defects that should be treated more seriously include:

- Splits across the grain of the wood.
- Splits orientated so that water can accumulate in them.
- Splits around connections such as bolt holes.
- Splits that are observed to be increasing in size.

4.8.6 Loose or damaged joints can seriously affect the strength of the structure, and in some cases can also cause serious accidents. Steel connection members, such as plates, bolts, pins and cables, may also be subject to corrosion, particularly in saline environments. Additionally, oak when wet gives off acids that can corrode ferrous connectors.

4.8.7 In glued-laminated timber elements, separation of the laminations may occur due to degradation of the adhesive. Delamination may be seen at the edges of the timber, where the edges of laminations are exposed, or on top or bottom surfaces as blistering.

## 4.9 CULVERTS

4.9.1 The general condition of trash screens and other ancillary items such as parapets or handrails should be noted. It may be appropriate for inspectors to comment on the apparent effectiveness of the trash screens or even suggest improvements as these items require frequent maintenance and, when blocked, can cause flooding. In some cases minor alterations to the layout and operation of the screen may improve effectiveness and reduce maintenance requirements.

4.9.2 The difficulties of providing access and ensuring safe working conditions may make the cost of Principal Inspections of some small diameter culverts disproportionate to the information gained. In appropriate cases it may therefore be acceptable to reduce the frequency of inspections requiring access to the barrel of the culvert. Formal guidance on decreasing inspections intervals is provided in the *Code of Practice [*1] and in *BD 63* [2] (also see paragraphs 2.2.20 and 2.4.18).

4.9.3 For a culvert to be considered for a reduced frequency of Principal Inspections, the following criteria should normally be satisfied:

- previous inspections have not detected significant defects or rapid deterioration;
- the culvert is functioning as intended;
- there is no evidence of settlement or other instability in the adjacent embankment or overlying carriageway;
- there is a clear line of sight through the culvert, so any blockages or gross deformations could be seen;
- inspections of either end of the culvert are carried out at the frequencies recommended in this Manual; and
- the culvert is not subject to frequent flooding (i.e. at or near full bore).

## 4.10 RETAINING WALLS

4.10.1 The principal defects which may occur in a retaining wall, are excessive movement of the whole wall (tilting, sliding, etc.) or of part of it (bulging, differential settlement, etc.) and problems arising from water seepage. These defects can also occur in other earth retaining structures such as bridge abutments and wing walls. Structural defects leading to excessive movement or misalignment which may be overlooked during close inspection may be apparent from a distance. Sighting along parapets, string courses or other features is a good method for detecting misalignments.

Highways Agency

4.10.2 The form of construction of the retaining wall may influence the location and types of defects. Cracks, for example, on the face of a wall may correlate with the location of steps constructed in the rear of a wall or bulging of a face may occur between adjacent counterforts.

4.10.3 Defects in flexible masonry retaining structures may stem from changed conditions in the vicinity of the structure, for instance adjacent construction works or clogged drainage paths.

4.10.4 Reinforced concrete retaining walls can suffer from corrosion due to the ingress of chloride ions from de-icing salts. Where walls face onto carriageways, they can become contaminated with chloride from the spray of passing traffic. Walls which support highways can also become contaminated if run-off from the carriageway is allowed to reach the top of the wall and either trickle down the face or seep down the back of the wall.

4.10.5 Inspectors should be particularly alert to changes in the loads imposed on retaining walls. These can frequently be caused by raising the ground level or storing materials behind the wall. Where there is vehicular access along the top of the wall, any changes in use should be noted.

## 4.11 MASTS, GANTRIES AND CANTILEVER SIGN STRUCTURES

4.11.1 Masts, gantries or cantilever sign structures are constructed from a variety of materials and are susceptible to the same forms of deterioration as other structures made of the same materials. Masts and gantries are relatively light structures, generally designed to be as slender as practicable. Consequently masts and gantries are more susceptible than other highway structures to structural failure arising from damage or deterioration. Inspectors should therefore be particularly alert for evidence of significant damage or deterioration.

4.11.2 The lower sections of supports are more vulnerable to corrosion because they are within the traffic splash and spray zones. Fixing brackets and straps for signs and electrical conduit on steel structures need careful inspection to confirm that they have not damaged any protective coating or impeded drainage. Since fixings may be of a relatively small cross-section, the amount of steel loss which can be tolerated may be small.


Highways Agency

4.11.3 Particular care should be given to identifying signs of foundation failure. The vertical alignment of the structure should be checked in both planes. Lack of verticality in any direction may indicate a foundation or fixing problem and its cause should be investigated.

4.11.4 Most masts and gantries support electrical equipment. Particular care is therefore required to ensure that the inspection can be undertaken safely (see paragraphs 3.3.21-3.3.25). Where it impinges on the inspection work, and whenever practicable, electrical apparatus should be isolated before inspection work proceeds in the vicinity. Any damaged electrical equipment should be reported immediately to the appropriate authority and work nearby should not proceed until the damaged item has been certified as safe.

4.11.5 The signs, lighting and other equipment supported by masts and gantries also require inspection and maintenance at regular intervals. This includes cleaning, bulk lamp changing and electrical inspection and testing. Whenever practicable, inspections of the structure should be co-ordinated with other inspections or routine maintenance. If an inspector observes what appears to be a significant defect on an item of equipment not within the scope of the structural inspection, he should report it without delay to the Supervising Engineer.

# Section 5
# Recording Inspection Findings

## 5.1 INTRODUCTION

5.1.1 The majority of the inspection work involves collecting relevant data and describing defects in terms of their type, location, extent, severity and, if possible, cause. Accurate reporting is essential in enabling the Supervising Engineer and others to make appropriate decisions concerning the safety and maintenance of the structure. In addition, reporting should be consistent so that inspectors, visiting the structure at a later time in the inspection cycle, can determine whether specific defects changed with regards to their extent or severity. Appropriate written notes should be captured as soon as an observation is made. After noting details of the defect, the notes should be checked to ensure that the supervising engineer will gain correct information on the overall condition of a structure.

5.1.2 Significant changes in the overall condition of a structure between distinct inspections may sometimes be attributed to different weather conditions at the time each inspection was undertaken. For example, rain, wet surfaces or poor light may affect observations and the width of a crack or joint may be dependent on temperature fluctuations. Therefore, it is important that the weather conditions at the time of the inspection and where appropriate during the previous few days should always be recorded.

5.1.3 Whenever appropriate photographs should be taken to record both individual defects and the general condition of the structure. To illustrate the scale, inclusion of an item such as a coin or ruler in the photograph, would be very useful when photographing details. Photographs taken from a distance to show a substantial part of the structure can also be very useful, especially in conjunction with close-ups of individual defects. Where access is difficult, it can be useful for future reference to photograph (or record on video) the access or traffic management arrangements adopted. These should supplement, not replace, the relevant parts of the method statement.

## 5.2 DATA CAPTURE AND INSPECTION PRO-FORMA

5.2.1 The purpose of recording defects is to both help decide on and prioritise any maintenance actions needed, and to monitor any development in the defects. Although there may be differing defect recording systems utilised by particular owners, the system should nevertheless support these two broad principles. A defect could be rated in terms of its influence on the condition of the element in which it is located, such as loss of functionality of the element, or it could be rated in terms of its action upon the element, for example the probability of causing damage to the element or (for an appearance related defect) the visual tolerability of the defect. Inspectors should check with the authority the form of the defect reporting system to be used.

5.2.2 Generally, inspection data should be recorded in a format that gives a clear and accurate description of the condition of a structure. The observed defects along with their associated severity and extent levels (see paragraph 5.3) should be recorded on an appropriate inspection pro-forma during General and Principal Inspections and, where relevant, Special Inspections.

5.2.3 An inspection pro-forma should be drawn up before an inspection is undertaken to specify the relevant information to be collected. The pro-forma should accommodate information on the form and materials of the structure, the referencing system, the span/panel and elements being inspected, the extent, severity and location of any defects, the recommended action and its priority, and inspector's comments. Some of the aforementioned information may be entered onto the pro-forma before the inspection.

5.2.4 The pro-forma should provide a simple and effective way of creating a consistent inspection reporting system that can be adjusted to suit the needs of individual owners. Typical pro-forma layouts that may be used during inspections are included in Appendix G. For example, the CSS inspection procedure [89 and 90], recommends that a generic pro-forma is used to perform the first inspection on a structure. After the inspection, the data collected should be used to create a structure specific pro forma comprising all the general structure data and only element types relevant to that structure, with the remaining elements deleted or their fields blanked-out.

5.2.5 Inspection reports should be signed by the inspector and dated in paper format as evidence in case of future potential claims by the public. The Supervising Engineer may review and sign General and Principal Inspection reports periodically and also identify maintenance needs.

## 5.3 ELEMENT CONDITION RATING

5.3.1 Some inspection recording methods rely on direct evaluation of element condition, whilst others rely on rating and locating individual defects. One recommended element condition rating process is contained in the *CSS Guidance Documents* [89, 90] and this is summarised Appendix G. Some authorities use alternative methods of deriving element condition ratings and as necessary, reference should be made to the particular owner guidance.

### Significance of Defects

5.3.2 Inspectors should immediately inform the Supervising Engineer, if in their opinion, a defect may compromise the integrity of the structure and the safety of the public.

5.3.3 Defects of a structural nature may in time cause dangerous or costly loss of fabric of the structure, and their significance may be influenced by the reserve structural capacity of the affected element. This type of defect therefore requires special consideration by both the inspector and the Supervising Engineer. It is recognised that the inspector may not know the reserve capacity of the various elements; therefore, the severity rating should be based on the inspector's observations. However, the inspector, should also indicate, in their opinion, whether consideration should be given to undertaking a structural assessment of the defect in order to confirm its structural significance. The inspector should base this comment on their knowledge of structural behaviour and professional judgement.

5.3.4 The Supervising Engineer will ultimately decide on the significance of a defect, and assessing the cause of the defect is an important step in determining this. It is important therefore that the inspector has an appreciation of likely causes and wherever possible relays this to the Supervising Engineer.

5.3.5 The Supervising Engineer may also need to assess, often by analytical means, whether a defect is affecting the required load carrying capacity of a highway structure. For example a defect may appear minor but could be the first indication of a serious problem. Diagonal cracks in a beam may be very fine and appear insignificant, whereas they could be the only sign that the beam may have inadequate shear capacity.

5.3.6 Where testing is undertaken in addition to or following on from a visual inspection, the severity rating of the defect should be reviewed once the results of these tests are known.

## 5.4 INSPECTION RECORDS

5.4.1 All inspections should result in a record, in a format appropriate to the inspection type. Standardised formats should be used for inspection records. The format should be clear, follow a logical sequence and incorporate all the necessary information. The inspection records support maintenance planning and management and should assist this process by adopting a relatively consistent format from one inspection cycle to the next.

5.4.2 It is recommended that, as a minimum, the information described below is provided in the relevant inspection report. In addition to this information all inspection records should also contain the date of the inspection, those responsible for undertaking the inspection, general information about the structure (e.g. name, reference and location) and details of the prevailing weather conditions at the time of the inspection (and where appropriate the weather during the previous few days).

**General Inspection**

5.4.3 A completed inspection pro-forma (see paragraph 5.2) may be sufficient as the General Inspection record; this should include as a minimum an indication of the location, severity, extent and type of any defects.

**Principal Inspection**

5.4.4 The record of a Principal Inspection should comment on the significance of any defects, include a completed inspection pro forma (normally as an appendix) and give a broad statement on the overall condition of the structure. The report should state if a Special Inspection is required, and where attention should be given to particular elements during the following General or Principal Inspection.

5.4.5 It is recommended that a Principal Inspection should also include a review of the completeness and accuracy of the inventory records. Any deficiencies in the records should be rectified as part of the Principal Inspection.

5.4.6 The following provides a checklist of records that should be considered for creation/updating by a Principal Inspection:

- The location, severity, extent and type of all defects on the structure, including, where appropriate, detailed descriptions and/or photographs (or sketches) of the defects that clearly identify their location and illustrate the severity/extent of damage.

- For bridges over roads the relevant headroom information based on measurements taken during the inspection.
- Any significant change (e.g. works carried out or deterioration) since the last Principal Inspection.
- Any information relevant to the integrity and stability of the structure.
- The scope and timing of any remedial or other actions required before the next inspection.
- The need for a Special Inspection, additional investigations and/or monitoring.
- A description of any testing that was undertaken, details of the information collected and an interpretation of the information.

5.4.7 Additional requirements specific to the authority or the structure characteristics may also be required from the Principal Inspection.

**Special Inspections**

5.4.8 The following may be used as a checklist for the minimum set of records created by a Special Inspection:

- Background and reasons for the Special Inspection.
- A detailed description of the condition of those parts of the structure that have been inspected including, where appropriate, photographs and/or sketches.
- Any significant change (e.g. works carried out or deterioration) since the last maintenance inspection to those parts of the structure that have been inspected.
- A description of any testing that was undertaken, details of the information collected and an interpretation of the information.
- Any information relevant to the integrity and stability of the structure.
- The scope and timing of any remedial or other actions required before the next inspection.
- The need for any additional investigations and/or monitoring.
- All aspects identified and/or required by the Monitoring Specification for structures managed in accordance with *BD 79* [4].

5.4.9 Additional requirements specific to the authority or the structure characteristics may also be required from the Special Inspection.

**Diving Inspections**

5.4.10 Where diving operations are required for Underwater Inspections a Diving Report Form should be filled in. An example of a completed form and accompanying sketches are shown in Appendix H.

## 5.5 DATA STORAGE

5.5.1 Inspection procedures are more effective when used in conjunction with a suitable computerised database or asset management system. The principal information obtained from all inspections should be entered onto the database, thus providing an up-to-date record of the condition of each structure. Information from previous inspections would be retained, thereby building up a profile of the change of condition over time.

5.5.2 In addition to providing for the entry of principal information, some databases have the facility to attach additional documents. Entire reports including comments, general text and photographs can be linked to the database. The use of electronic data storage, browsing and retrieval methods can improve working efficiency.

## 5.6 EVALUATION OF INSPECTION RESULTS

5.6.1 The results of an inspection should be sufficient to determine whether a structure is safe for use and fit for purpose. The inspection results should trigger urgent action if necessary and enable the identification of current and future maintenance, prioritisation of work and an approximate estimation of the cost. The *Code of Practice* [1] provides guidance on how inspection results should be used in the maintenance planning process.

5.6.2 The *Condition Performance Indicator* [91], formerly known as the C*SS Bridge Condition Indicator* [92], can be used to provide a condition score for an individual structure, a group of structures and a stock of structures. The condition scores should be monitored over time to assess whether the condition is declining, improving or remaining constant as maintenance is carried out.

# Section 6
# Input to Maintenance Planning Process

6.1.1 Maintenance planning and management is an on-going activity and as such requires up-to-date and relevant information on structural condition and performance to ensure the correct work is being planned and to assess the effectiveness of previous work.

6.1.2 Inspections, primarily General, Principal and Special Inspections, generally provide the most up-to-date and comprehensive data on the condition of highway structures and as such are a key input for maintenance planning. The *Code of Practice* [1] provides guidance on how inspection results and other structural performance information should be used to inform the maintenance planning process.

# Section 7
# References for Part C


1. *Management of Highway Structures: Code of Practice*, TSO, 2005.

2. BD 63 *Inspection of Highway Structures*, DMRB 3.1.4, TSO.

3. BA 74 *Assessment of Scour at Highway Bridges*, DMRB 3.4.21, TSO

4. BD 79 *The Management of Substandard Highway Structures*, DMRB 3.4.18, TSO.

5. BA 35 *Inspection and Repair of Concrete Highway Structures*, DMRB 3.3.2, TSO.

6. BA 50 *Post-tensioned Concrete Bridges: Planning, Organization and Methods for Carrying Out Special Inspections*, DMRB 3.1.3, TSO.

7. BA 30 *Strengthening of Concrete Highway Structures Using Externally Bonded Plates*, DMRB 3.3.1, TSO.

8. *Technical Report 57: Strengthening Concrete Structures using Fibre Composite Materials: Acceptance, Inspection and Monitorin*g, Concrete Society, Crowthorne, 2003.

9. BD 7 *Weathering Steel for Highway Structures*, DMRB 2.3.8, TSO.

10. BS EN 1337 *Structural Bearings – Part 10: Inspection and Maintenance*, British Standards Institution, 2003.

11. BD 65 *Design Criteria for Collision Protector Beams*, DMRB 2.2.5, TSO.

12. *The Operation and Maintenance of Bridge Access Gantries and Runways*, Institution of Structural Engineers, London, 2007.

13. *Factories Act*, 1961, HMSO.

14. *Well-lit Highway: Code of Practice for Highway Lighting Management*, TSO, 2005.

15. BD21 *The Assessment of Highway Bridges and Structures*, DMRB 3.4.3, TSO.

16. *Construction (Design and Management) Regulations 1994* (SI 1994, No. 3140), HMSO (Amended SI 2000, No. 2380; Additional revisions are expected to come in to force in April 2007).

17. *Health and Safety at Work Act etc*, 1974, HMSO.

18. *Management of Health and Safety at Work Regulations 1999* (SI 1999, No. 3242), HMSO.

19. *Construction (Health, Safety and Welfare) Regulations 1996* (SI 1996, No. 1592), HMSO.

20. *Managing Construction for Health and Safety – Construction (Design and Management) Regulations, 1994: Approved Code of Practice*, Health & Safety Executive, HSE Books, Sudbury, 2001.

21. *Management of Health and Safety at Work – Management of Health and Safety at Work Regulations 1999: Approved Code of Practice and Guidance L21*, Health & Safety Executive, HSE Books, Sudbury, 2000.

22. *The Personal Protective Equipment at Work Regulations 1992 – Approved Code of Practice L25*, Health & Safety Executive, HSE Books, Sudbury, 1992.

23. *Construction Health & Safety Manual (2 Volumes)*, Construction Confederation, Construction Industry Publications, Birmingham, 1998.

24. *Construction (Design and Management) Regulations (Northern Ireland) 1995* (SI 1995, No. 209), HMSO (Amended SR 2001, No. 142).

25. *Roads Service Safety Manual (RSSM)*, Department of the Environment for Northern Ireland, Belfast, 1999.

26. *The Control of Asbestos at Work Regulations 2002* (SI 2002, No. 2675), HMSO.

27. *Transport and Works Act 1992*, HMSO.

28. *Infection at Work – Controlling the Risks: A Guide for Employers and the Self Employed on Identifying Assessing and Controlling the Risks of Infection in the Workplace*, Health & Safety Executive, Advisory Committee on Dangerous Pathogens, 2003.

29. *The Approved List of Biological Agents*, Health & Safety Executive, Advisory Committee on Dangerous Pathogens, 2004

30. *The Control of Substances Hazardous to Health Regulations 2002: Approved Code of Practice and Guidance L5*, Health & Safety Executive, HSE Books, Sudbury, 2002.

31. *Electricity at Work Regulations 1989* (SI 1989, No. 635), HMSO.

32. *Electrical Equipment (Safety) Regulations 1994* (SI 1994, No. 3260), HMSO.

33. *HS(G)151 Protecting the Public – Your Next Move*, Health & Safety Executive, HSE Books, Sudbury, 1997.

34. *Management of Health and Safety at Work Regulations (Northern Ireland) 2000* (SR 2000, No. 338), HMSO (Amended SR 2006, No. 255).

35. INDG163 (rev2) *Five Steps to Risk Assessment*, Health & Safety Executive, HSE Books, Sudbury, 2006.

36. SP121 *Temporary Access to the Workface: A Handbook for Young Professionals*, CIRIA, London, 1995.

37. *Traffic Signs Manual, Section 8: Traffic Safety Measures and Signs for Road Works and Temporary Situations, Part 1: Design*, Department of Transport, TSO, London, 2006.

38. *Traffic Signs Manual, Section 8: Traffic Safety Measures and Signs for Road Works and Temporary Situations, Part 2: Operations*, Department of Transport, TSO, London, 2006.

39. *Safety at Street Works and Road Works – A Code of Practice*, 2nd Edition, HMSO, 2002.

40. *Traffic Signs and Lighting,* DMRB Volume 8, TSO.

41. *Countryside Code*, Countryside Access: http://www.countrysideaccess.gov.uk.

42. *Countryside Code*, Countryside Council for Wales: http://www.ccw.gov.uk.

43. *Countryside Code*, Scottish Natural Heritage: http://www.snh.org.uk.

44. *Countryside Code*, Countryside Access and Activities Network for Northern Ireland: http://www.countrysiderecreation.com.

45. *Guide to Inspection of Underwater Structures*, Institution of Structural Engineers, London, 2001.

46. *Health and Safety at Work (Northern Ireland) Order* 1978 (SI 1978, No. 1039), HMSO (Amended SI 1998 No. 2795).

47. *Diving at Work Regulations 1997* (SI 1997, No. 2776), HMSO.

48. Health & Safety Executive *Commercial Diving Projects Inland / Inshore: Approved Code of Practice L104*, HSE Books, Sudbury, 1998.

49. *Safe Work in Confined Spaces: Approved Code of Practice, Regulations and Guidance L101*, Health & Safety Executive, HSE Books, Sudbury, 1997.

50. *Work at Height Regulations 2005* (SI 2005, No 735), HMSO.

51. *INDG402 Safe Use of Ladders and Stepladders – An Employers' Guide*, Health & Safety Executive, HSE Books, 2005.

52. BS EN 280 *Mobile elevating work platforms: Design calculations, Stability Criteria, Construction, Safety, Examinations and Tests*, British Standards Institution, Milton Keynes, 2001.

53. HS(G)19 *Safety in Working With Power-Operated Mobile Working Platforms*, Health & Safety Executive, HSE Books, Sudbury, 1982.

54. *Guidelines on Use of Roped Access Methods for Industrial Purposes*, 2nd Edition, Rev 1., Industrial Roped Access Trade Association, 2002.

55. *Construction (Head Protection) Regulations 1989* (SI 1989, No. 2209), HMSO.

56. *Personal Protective Equipment at Work Regulations 1992* (SI 1992, No. 2966), HMSO.

57. *Control of Noise at Work Regulations* 2005 (SI 2005, No. 1643), HMSO.

58. *INDG362(rev1) Noise at work – Guidance for employers on the Control of Noise at Work Regulations* 2005, Health & Safety Executive, HSE Books, 2005.

59. *INDG363(rev1) Protect your hearing or lose it!*, Health & Safety Executive, HSE Books, 2005.

60. BD 62 *As Built, Operational and Maintenance Records for Structures*, DMRB 3.2.1, TSO.

61. *Special Issue: Historic Concrete*, Institution of Civil Engineers (Ed.), Proc. Inst. Civ. Engrs Structs & Blgs, 116, Aug/Nov, 1996.

62. *Historical Structural Steelwork Handbook*, Bates W, British Constructional Steelwork Association, London, 1984.

63. *The Maintenance of Brick and Stone Masonry Structures*, Sowden AM (Ed.), E & F N Spon, London, 1990.

64. *Ecology and Nature Conservation*, DMRB 11.3.4, TSO.

65. HA 84 *Nature Conservation and Biodiversity*, DMRB 10.4.1, TSO.

66. *Wildlife and Countryside Act*, 1981, HMSO (Amended SI 2004, No. 1487).

67. *Conservation (Natural Habitats, etc.) Regulations 1994* (SI 1994, No. 2716), HMSO.

68. *Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995* (SI 1995, No. 380), HMSO (Amended SI 2004, No. 435).

69. *Wildlife (Northern Ireland) Order 1985* (SI 1985, No. 171 (NI 2)), HMSO (Amended SI 1995, No. 761 (NI6)).

70. *The Conservation of Bats in Bridges Project: A Report on the Survey and Conservation of Bat Roosts in Bridges in Cumbria*, Billington GE & Norman GM, English Nature, Peterborough, 1997.

71. HA 80 *Nature Conservation Advice in Relation to Bats*, DMRB 10.4.3, TSO.

72. HA 81 *Nature Conservation Advice in Relation to Otters*, DMRB 10.4.4, TSO.

73. *The Protection of Badgers Act 1992*, HMSO.

74. HA 59 *Mitigating Against Effects on Badgers*, DMRB 10.4.2, TSO.

75. *Water Resources Act 1991*, HMSO.

76. *Control of Pollution Act 1974* (SI 1988, No. 818), HMSO (Amended 1989 c.14).

77. *Water (Northern Ireland) Act 1972*, HMSO.

78. *The Air Quality Strategy for England, Scotland Wales and Northern Ireland, Working Together for Cleaner Air*, Department of the Environment, Transport and the Regions, HMSO, 2000.

79. BA 88 *Management of Buried Concrete Box Structures*, DMRB 3.3.5, TSO.

80. *Technical Report 54 Diagnosis of Deterioration in Concrete Structures*, Concrete Society, 2000.

81. *Technical Guide 2: Guide to Testing and Monitoring the Durability of Concrete*, Concrete Bridge Development Group, Concrete Society, Slough, 2002.

82. *Structural Effects of Alkali-Silica Reaction: Technical Guidance on Appraisal of Existing Structures*, Institution of Structural Engineers, 1992.

83. BA 67 *Enclosure of Bridges*, DMRB 2.2.8, TSO.

84. BA 87 *Management of Corrugated Steel Buried Structures*, DMRB 3.3.4, TSO.

85. *Synthesis 353: Inspection and Maintenance of Bridge Stay Cable Systems – A synthesis of Highway Practice, Transportation Research Board*, National Cooperative Highway Research Programme, Washington D.C., 2005.

86. *Masonry Arch Bridges: Condition Appraisal and Remedial Treatment*, Publication C656, CIRIA, 2006.

87. *Appraisal of Existing Iron and Steel Structures*, Bussell M, Steel Construction Institute, 1997.

88. *BRE Good Repair Guide 34: Repair and Maintenance of FRP Structures*, S Halliwell & E Suttie, 2003.

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

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

91. *Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator*, UK Bridges Board, 2007.

92. *Bridge Condition Indicators Volume 3: Guidance Note on Evaluation of Bridge Condition Indicator*, County Surveyors Society, 2002.