

Roads Liaison Group

Please note that Complementary Guidance to this Code is now available.

The Complementary Guidance has the same status as the code.

Please click here for further info: http://www.ukroadsliaisongroup.org/bridges/code_of_practice.htm

Management of Highway Structures

A Code of Practice

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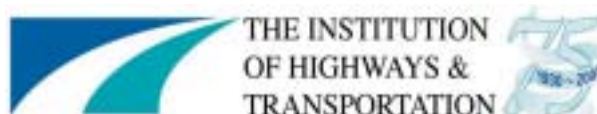
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Full details of project sponsors, steering group members and technical advisors are provided in the Acknowledgements section on page 313.

Foreword

by the Chairman of the UK Bridges Board

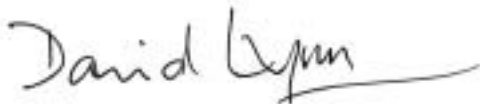


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The effective management of bridges and other highway structures is fundamental to the transport infrastructure of the United Kingdom. This document has been produced to assist bridge managers and practitioners with that task.

This is an important document which has been promoted by the UK Bridges Board and funded by the Department for Transport.

On behalf of the UK Bridges Board I am pleased to commend this document to you and advise that all highway authorities and other owners adopt the recommendations set out in the Code in a measured way.

A handwritten signature in black ink that reads "David Lynn". The signature is written in a cursive style with a long horizontal stroke at the end.

David Lynn
Chairman of UK Bridges Board
September 2005

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Executive Summary

INTRODUCTION

It is widely recognised that a well managed transport infrastructure is vital to the economic stability, growth and social wellbeing of a country. Bridges and other highway structures are fundamental to the transport infrastructure because they form essential links in the highway network.



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The management of highway structures in the UK is undertaken by a variety of *highway authorities and other owners*, e.g. local authorities, trunk road agencies, Network Rail, BRB (Residuary), Environment Agency, British Waterways, London Underground Limited, Transport for London and many private owners.

In the UK an overarching authoritative document was not hitherto available that described how authorities should manage highway structures to ensure that they are *Safe for Use and Fit for Purpose*. This has resulted in the use of a wide range of management practices for highway structures which differ considerably in their objectives, approach, standards and processes and they have not always been fully effective and efficient.

PURPOSE OF THE CODE

The purpose of this Code is to provide authoritative guidance on highway structures stewardship duties and the development of recognised Good Management Practice. The Code seeks to promote a degree of management consistency that, while enabling some individual flexibility, will form the framework for harmonisation and coordination of practices across the UK and the sharing of experience amongst authorities.

The Code has been developed around an asset management approach which allows bridge management activities to be brought together into a systematic and holistic framework for all the highway infrastructure assets. The Code assists authorities to compare their current practice against recommended Good Management Practice, determine any gaps in practice, and identify how they should prioritise their needs and progress towards Good Management Practice. The implementation of the Code is expected to provide highway structures that deliver the agreed network Levels of Service, in conjunction with the other highway assets, to the public in a most cost effective manner.

OBJECTIVES OF THE CODE

The objectives of the Code are to encourage and assist highway authorities and other owners to implement Good Management Practice, harmonise practices, coordinate approaches and share their experiences and practices.

The Code emphasises the need for a holistic approach to highway structures management that gives due consideration to the wider highway network and local environment in which the structures exist.

SCOPE OF THE CODE

This Code covers all aspects of highway structures management, except for the design of new structures or alterations/upgrades to existing structures. Reference should be made to existing codes and standards for guidance on design.



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The guidance has been drawn up specifically for highway structures associated with the adopted road network. In addition the general principles apply to structures associated with all other highways that are used by the public, e.g. segregated footpaths and cycle routes, and the Public Right of Way network.

The types of highway structure covered by the Code are those within the boundaries of the highway or which otherwise materially affect it and include bridges, footbridges, cycleway bridges, bridleway bridges, accommodation bridges, occupation bridges, subways, underpasses, culverts, tunnels, retaining walls, sign/signal gantries and cantilever road signs.

The principles and processes described in the Code are generally applicable within the UK but, where the specific government policy and legal context is relevant, the context referred to is that in England. Where necessary, the national variations relevant in Wales, Scotland and Northern Ireland are also referenced.

STATUS OF THE CODE

The Code is published under the aegis of the UK Bridges Board with the endorsement of the UK Roads Liaison Group. The Code is a companion to and should be used alongside:

- *Well-Maintained Highways: Code of Practice for Highway Management*
- *Well-Lit Highways: Code of Practice for Highway Lighting Management*

The recommendations of this Code are based on accepted good practice but are not explicitly mandatory on owners of highway structures. However, in cases of claims or legal action the Code may be treated as a relevant consideration. It is recognised that affordability and local circumstances can impose constraints on implementing certain recommendations and therefore a degree of flexibility is provided in the Code for achieving the recommendations.

ORGANISATION OF THE CODE

Section 1 (*Introduction*) provides the background to the Code and introduces the purpose, scope and status. An overview of asset management is given together with a summary of the purpose and contents of each section. An introduction to using the Code is provided and includes sub-sections on getting started and implementation.

The remainder of the Code is organised around the key themes of highway structures management as shown schematically in Figure 1.

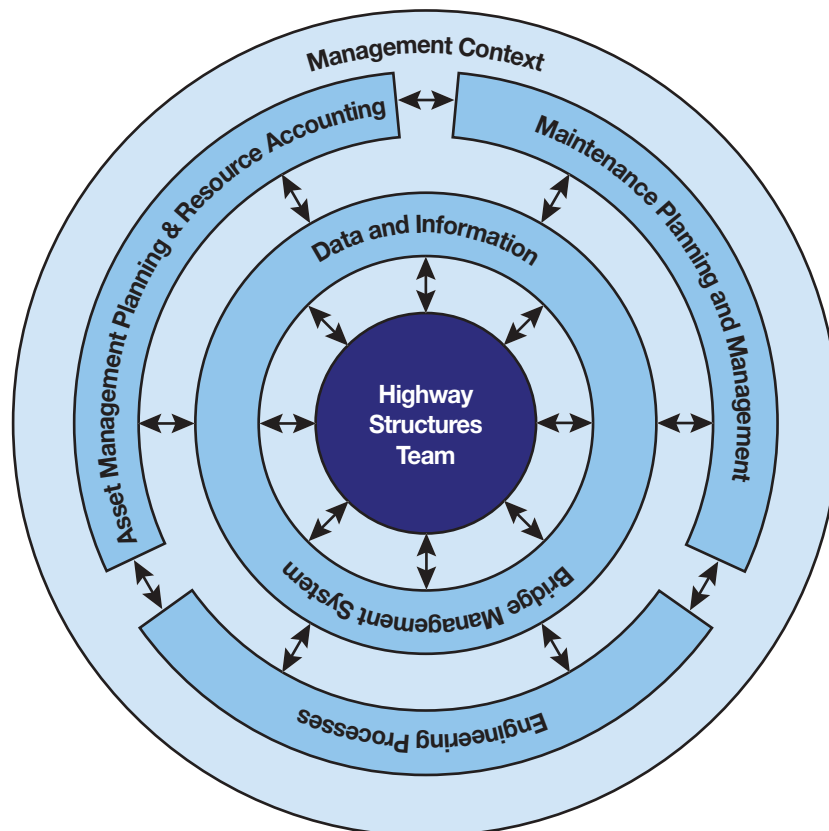


Figure 1: Organisation of the Code

Three of the themes relate to important processes undertaken by the Bridge Manager and the *Highway Structures Team*:

- *Asset Management Planning & Resource Accounting*
- *Maintenance Planning and Management*
- *Engineering Processes.*

These processes are supported by appropriate *Data and Information*. The *Data and Information* is normally stored in a computerised *Bridge Management System*. The *Bridge Management System* enables the *Data and Information* to be manipulated during the different processes.

The aforementioned management themes (processes, data and systems) are carried out within the overall *Management Context*. The *Management Context* relates to the rules, requirements and constraints that the *Bridge Manager* has to operate within, e.g. Government policy, legal, procedural, social and environmental requirements.

Each of the key themes is summarised in the following.

Highway structures team

The specific responsibilities, organisation and size of the highway structures team differ between authorities, but as a minimum there should be a bridge manager who takes overall responsibility for highway structures management. The bridge manager should be supported by bridge engineers (providing a range of expertise), technicians, inspectors etc, to create a team that is appropriate to the size and nature of the highway structures stock and the duties to be undertaken by the authority.

Management Context

It is important that those individuals involved in the management of highway structures have a full appreciation of the management context in which they have to operate. Specialist input on specific issues such as sustainability requirements should be sought as and when required.



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Section 2 (*Management context*) provides the background and an overview of the large number of issues that can have an impact on the management of highway structures. Guidance is provided on competence and training, Government policy, legal and procedural requirements, Health and Safety, environmental and sustainability requirements, stakeholder consultation and interaction with other owners.

Asset Management Planning and Resource Accounting

Asset Management is a formal discipline that is accepted across the infrastructure and property sectors, in the UK and internationally, as representing good practice for the management of physical assets. Asset Management is defined as:

Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.

Framework for Highway Asset Management, County Surveyors Society, 2004

Asset Management is an authority-wide initiative that seeks to integrate practices and systems across disciplines, e.g. roads, structures and lighting. To assist bridge managers to appreciate the overall Asset Management approach, Section 3 (*Asset Management Planning*) provides an overview of Asset Management at an authority-wide level and then goes on to describe an asset management planning process appropriate for highway structures. The asset management planning process involves predicting the long term work volumes, work phasing and determining funding levels required to deliver the authority's long term goals and objectives. Completing the asset management planning process produces the highway structures input to an authority's Transport Asset Management Plan.

Section 3 is supported by the financial planning and resource accounting procedures described in Section 4 (*Resource Accounting and Financial Planning*). Section 4 provides guidance on different levels of financial planning, from short term budgets to long term Transport Asset Management Plans. The principles and requirements of Resource Accounting are introduced, and capitalisation policy and classification of expenditure on highway structures is discussed. The asset valuation process for highway structures is summarised.

Maintenance Planning and Management

Maintenance involves repair of damage caused by deterioration, vehicle impact or vandalism, slowing down or preventing the deterioration process and, where appropriate, enhancing the structure to meet the changing demands of users.

The purpose of maintenance planning and management is to develop and implement cost effective and sustainable maintenance plans for highway structures that support the safe operation of the network while delivering the required Levels of Service. The maintenance planning and management process enables the bridge manager to deliver the authority's long term goals and objectives by developing short and medium term maintenance plans that align with the long term Transport Asset Management Plan.

Section 5 (*Maintenance Planning and Management*) describes a formalised process for planning and managing maintenance works. The process includes the identification of needs, value management, value engineering, developing a forward work plan and work scheduling and the delivery of maintenance work. Guidance is provided on suitable techniques to adopt for each step of the process.

Engineering Processes

The Code covers three engineering processes that are central to highway structure management:

- Section 6 (*Inspection, Testing and Monitoring*) - the purpose of inspection, testing and monitoring is to confirm that the highway structures stock is safe for use and fit for purpose and to provide the data required for management. Guidance is provided on the inspection regime authorities should adopt and the issues to consider when planning and undertaking testing and monitoring.

- Section 7 (*Assessment of Structures*) - the purpose of the assessment of a highway structure is to determine the ability or capacity of the structure to carry the loads which are imposed upon it and which may reasonably be expected to be imposed upon it in the foreseeable future. The assessment provides valuable information for managing the safety and serviceability of highway structures. Guidance is provided on a suitable regime for structural review and (re)assessment of highway structures.
- Section 8 (*Management of Abnormal Loads*) – the movement of abnormal loads on highways needs to be carefully managed so that large and heavy vehicles only use those parts of the road network that can safely accommodate them. Guidance is given on the responsibilities and the requirements for authorities to establish and maintain a system to receive notifications from hauliers and advise them in respect of abnormal load movements. Also, key features of alternative systems that could be used for assessing the suitability of notified vehicles on the proposed route are summarised.

Data and Information

Data and information form the basis of the processes involved in highway structures management. Data collection, storage, management and retrieval are expensive and potentially resource intensive tasks and a planned and considered approach should be adopted.



Section 9 (*Asset Information Management*) describes an information management process that should be used to identify current data gaps and plan data collection, storage and on-going review. To assist with this, Section 9 categorises and lists the data required to support the processes described in the Code.

Bridge Management System

The purpose of a Bridge Management System (BMS) is to enable storage, manipulation, management and retrieval of *Data and Information* and to support *Engineering Processes, Asset Management Planning and Resource Accounting and Maintenance Planning and Management*. A BMS should achieve this effectively and efficiently, align with recognised requirements (e.g. Condition Indicator), be compatible with other systems for data sharing/transfer (e.g. Asset Valuation) and be reflective of the size and nature of an authority's highway structures stock.

Section 10 (*Framework for a Bridge Management System*) provides guidance on the functionality a BMS should have. This is intended to be used by authorities as a checklist in assessing the suitability of in-house or commercial BMS to support the processes described in the Code.

IMPLEMENTATION OF THE CODE

The Code represents a substantial body of guidance on highway structures management and is likely to differ in places from the management practices currently used by some authorities. Section 11 (*Implementation of the Code*) is provided to assist authorities in identifying gaps in their current practice and in developing an implementation plan to close the gaps in a phased manner in order to progress towards the Good Management Practice recommended by the Code.

The guidance provided in Section 11 covers four key tasks (1) Getting Started, (2) Recommendations, (3) Milestones and Actions and (4) Developing an Implementation Plan. These tasks are summarised below.

Getting Started

The "Getting Started" phase is intended to assist the development of an understanding of the Code. This may include examining the Code, attending regional and national events, holding an internal workshop and planning the way forward to implement the recommendations in the Code.

Recommendations

The Code provides guidance on improving current management practice to achieve Good Management Practice that is relevant to local circumstances. The Code's recommendations are:

1. Suitably qualified and experienced personnel, including contracted staff, should be used to implement the Good Management Practice embodied in this Code. There should be a programme of training and Continuing Professional Development (Section 2).
2. Up-to-date background information should be maintained on the overall management context to provide an appropriate basis for meeting the requirements and regulations for the management of highway structures. This should include Government transport policy, authority's transport policy, legal, Health and Safety, environmental, and sustainability requirements (Section 2).
3. An Asset Management Regime should be developed for highway structures that is appropriate to the size and character of the stock. The regime should seek to be consistent with those for other transport assets (Section 3).

4. A highway structures representative should be appointed to the authority's asset management team (Section 3).
5. A robust long term asset management planning process should be developed and implemented for highway structures (Section 3).
6. Performance measures and targets should be established for highway structures which align with and support the strategic goals and objectives and Levels of Service (Section 3).
7. Financial plans should be prepared covering short, medium and longer term time horizons for the maintenance of highway structures. The plans should provide the basis for targeting investment in achieving the authority's Strategic Transport Plan, e.g. LTP or LIP (Section 4).
8. Appropriate policies and procedures should be implemented for the accounting of expenditure on structures in accordance with financial reporting standards, established accounting practices and guidance (Section 4).
9. Appropriate policies and procedures should be implemented for the asset valuation of highway structures for inclusion in the authority's Balance Sheet. The valuation should follow financial reporting requirements and guidance provided in *CSS Guidance Document for Highway Infrastructure Asset Valuation* (Section 4).
10. A formalised maintenance planning and management process should be implemented that identifies needs, prioritises maintenance and produces cost effective and sustainable short to medium term work plans that are consistent with the long term Transport Asset Management Plan. The processes should cover the complete maintenance planning and management cycle (Section 5).
11. An inspection regime should be implemented for all highway structures, supplemented by testing and monitoring where appropriate. The inspection regime should include Acceptance, Routine Surveillance, General, Principal, Special and Safety Inspections as necessary (Section 6).
12. A regime of structural reviews should be implemented whereby the adequacy of structures to carry the specified loads is ascertained when there are significant changes to usage, loading, condition or the assessment standards. A structural review should identify structures which need a full assessment (Section 7).
13. A prioritised programme of structural review should be put in place to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards. Where a requirement for assessment is identified, such assessments should be carried out in accordance with national standards which are current at the time (Section 7).
14. All owners or managers of highway structures should establish and maintain a system to receive notifications from hauliers in respect of General Order abnormal load movements. The system should enable hauliers to be advised within the statutory time limits if there is any reason why the movement should not proceed. The system should also be able to manage the movement of Special Order vehicles in accordance with national standards and regulations (Section 8).

15. Information requirements for implementing Good Management Practice should be established and gaps in current information identified. A prioritised programme should be put in place to capture missing information (Section 9).
16. Data and information capture, verification, transfer and storage processes and practices should be established and continually reviewed (Section 9).
17. A Bridge Management System appropriate to the size and characteristics of the highway structures stock and needs of the authority should be implemented to support the Good Management Practice set out in this Code (Section 10).

Milestones and Actions

The recommendations of the Code should be implemented in a measured way. To assist this, the recommendations are supported by suggested actions which are grouped under three milestones and presented at the end of each section of the Code. The milestones are defined below.

1. **Milestone One** is intended broadly to include the adoption of processes necessary to provide highway structures that are *safe to use, inspect and maintain*.
2. **Milestone Two** encompasses Milestone One and is also intended broadly to include the adoption of additional processes necessary to provide highway structures that are *fit for purpose* and meet Government requirements. Milestone Two represents an interim step on the progression towards Milestone Three.
3. **Milestone Three** encompasses Milestones One and Two and additionally requires the adoption of processes necessary to deliver the agreed Levels of Service (and Performance Targets) at minimum whole life costs and to align with current and emerging Government policy objectives. This represents the full implementation of the Good Management Practice set out in this Code.

The milestones should be achieved in the order shown. However, this does not preclude progressing some actions in **Milestone Three** before **Milestone Two** is fully achieved. Progressing **Milestone Two** and **Three** actions should not delay achievement of **Milestone One** which should be completed as a matter of urgency.

Developing an Implementation Plan

Each authority should develop a plan for implementing the Good Management Practice that is appropriate to the size and character of its stock of highway structures and taking account of existing constraints and local circumstances. A formal process for developing the implementation plan is provided (Figure 2) which includes:

1. **Identify Good Management Practice (To-Be)** – the desired practice should be taken as the Good Management Practice recommended by the Code.
2. **Determine Current Practice (As-Is)** – a review of the current management practices to determine the starting position.
3. **Perform Gap Analysis** – a comparison of the As-Is and To-Be practices to identify the gaps. The gap analysis should include the assessment of costs and resources required to close the gap, the benefits of closing the gap and

the resources/training needed to sustain the To-Be position once in place. The need to close the identified gaps should be prioritised using relevant criteria.

4. **Develop Implementation Plan** – convert the gap analysis into an implementation plan. The plan should identify the activities and timeframes together with the resources required to achieve it.
5. **National and local timeframes and requirements** – the implementation plan should be informed by these timeframes and requirements. In some cases this may necessitate a revision of the plan.
6. **Deliver Implementation Plan** – implementation and delivery of the plan as a formal project.
7. **Monitoring and Feedback** – practices should be periodically reviewed to assess the effectiveness of the implementation plan. If necessary the implementation plan should be revised.

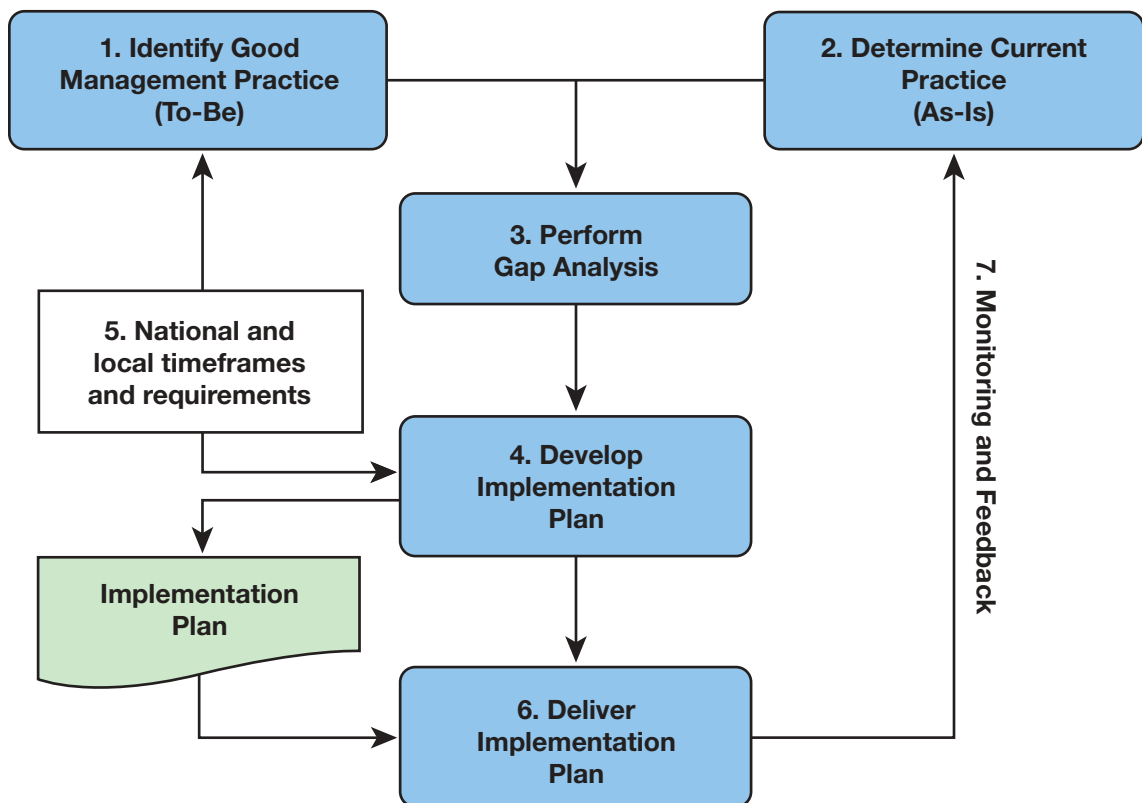


Figure 2: Process for developing an implementation plan

The implementation plan should be managed as a formal project and have a project manager, budget and resources allocated. The implementation plan should be reviewed annually and revised when appropriate.

Glossary of Terms

The purpose of the glossary is to establish a common set of terms for highway structures engineering and management. The glossary does not aim to be comprehensive, but includes the more common highway structures terms. The glossary is divided into three parts:

1. Definitions of structure type, e.g. bridge, culvert, retaining wall.
2. Definitions of component types and construction forms, e.g. box culvert, beam, spandrel.
3. Other definitions used in the code, e.g. asset valuation, bridge manager, authority.

Where terms used in this Code are found in *Well Maintained Highways: Code of Practice for Highway Maintenance*, the same definitions apply.

Structure type

Structure	A construction that supports itself and carries load.
Highway structure	Any bridge or other structure that impinges in any way within the footprint of the highway or that materially affects the support of the highway or land immediately adjacent to it and that meets the dimensional criteria defined below or elsewhere in the Code.
Bridge	<p>A structure with a span of 1.5m or more spanning and providing passage over an obstacle, e.g. watercourse, railway, road, valley. This category also covers subways, footbridges and underpasses.</p> <p>However, bridge managers should be aware that BD 2/02 (<i>Technical Approval of Highway Structures</i>) applies to all highway structures with a clear span or internal diameter greater than 0.9m.</p>
Cantilever road sign	A structure with a single support that projects over the highway in order to carry a traffic sign.
Cellar and vault	An underground room or chamber with a maximum plan dimension of 1.5m or more.
Culvert	<p>A drainage structure with a span of 1.5m or more passing beneath a highway embankment that has a proportion of the embankment, rather than a bridge deck, between its uppermost point and the road running courses. Culverts are normally rectangular or circular in cross section.</p> <p>However, bridge managers should be aware that BD 2/02 (<i>Technical Approval of Highway Structures</i>) applies to all highway structures with a clear span or internal diameter greater than 0.9m.</p>
Retaining wall	<p>A wall associated with the highway where the dominant function is to act as a retaining structure.</p> <p>However, bridge managers should be aware that <i>Section 167</i> of the <i>Highways Act 1980</i> gives highway authorities special powers in relation to highway retaining walls of height greater than 4'6" (approximately 1.35m).</p>
Road tunnel	A tunnel with an enclosed length of 150 metres or more through which a road passes.
Sign/signal gantry	A structure spanning the highway, the primary function of which is to support traffic signs and signalling equipment.

Components types and construction form

Useful diagrams explaining some of the following terms can also be found in:

1. Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting, County Surveyors Society, April 2002
2. Addendum to Bridge Condition Indicators Volume 2, County Surveyors Society, August 2004
3. Bridge Management in Europe, BRIME, March 2004.

Two important definitions for highway structures are:

Superstructure The horizontal components of a structure, generally above the bearings, that directly support the traffic loads (e.g. bridge deck and longitudinal beams) and transfer the loads to the substructure.

Substructure The vertical components of a structure (e.g. piers, columns and foundations), generally below the bearings, that support the superstructure and transfer the loads to the supporting ground.

The following definitions are provided in alphabetical order:

Abutment Part of the substructure that supports the extreme ends of the superstructure and transfers the loads to the foundations or ground. Abutments generally retain or support the approach embankment and bearings. An abutment should provide adequate clearance between the superstructure and obstacle crossed. Common types include:

Bank-seat abutment Abutments of small vertical height that are normally situated on top of a natural or man-made bank (e.g. banks of watercourses, embankments) and do not provide a significant retaining function. The combination of the bank and the bank-seat abutment provide the clearance required.

Cantilever abutment An abutment wall that is rigidly fixed to the foundation and transfers traffic loads and earth pressures to the foundations principally by bending action. Similar to a cantilever retaining wall.

Gravity abutment An abutment that resists horizontal forces through its own self-weight and normally transfers vertical loads directly to the ground. Similar to a gravity retaining wall.

Approach embankment A bank formed above the natural ground level that creates the approach to a bridge. The purpose of an approach embankment is to raise the road level to align with the bridge deck level.

Approach slab	A slab positioned below the road surface on the approach to a bridge, the end of which normally rests on the back of the abutment. The purpose of the approach slab is to provide a smooth transition for traffic from the road to the bridge and vice versa. Approach slabs are normally made of reinforced concrete.
Apron	A horizontal slab/mattress built into the bed of the watercourse around piers, abutments, culverts and watercourse banks, possibly in conjunction with revetments. The purpose of an apron is to provide scour protection to the bed of the watercourse.
Arch	A curved beam or slab that functions primarily in compression and produces both vertical and horizontal reactions at its supports.
<i>Arch bridge</i>	A bridge where the primary load bearing element is an arch that spans between abutments/piers.
<i>Jack arch</i>	Arches sprung between the bottom flanges of longitudinal or transverse spanning beams forming the soffit of the bridge deck.
Beam	A linear structural member that spans from one support to another and may be simply supported or continuous. Beams are part of the superstructure and common types include:
<i>Primary beam</i>	A primary, or main, load carrying beam in a bridge supports the bridge deck and transfers the traffic loads and superstructure weight (including their own self weight) to the substructure (via bearings on some forms of structure). Primary beams normally span parallel to the direction of traffic flow.
<i>Girder</i>	Performs the same function as a beam but is normally metal and has been built up, e.g. flanges and web cast separately and welded together.
<i>Parapet beam/cantilever</i>	A beam/cantilever, the dominant function of which is to support the parapet, and sometimes the footpath or verge that runs beside the road (also see cantilever).
<i>Tie beam/rod</i>	A beam (or rod) that acts in tension. It normally connects two parts of a structure in order to prevent them moving apart due to the applied forces. Examples are the horizontal beam of a tied-arch and tie-rods linking the abutments/piers of a masonry arch.
<i>Transverse beams</i>	Secondary load bearing beams that transfer the traffic loads to the main beams. Transverse beams normally span between the primary beams and are perpendicular to the direction of traffic flow.
Bearing	A component that provides the connection between the superstructure and substructure, the purpose of which includes all or some of the following: <ul style="list-style-type: none">• To transfer vertical/horizontal loads from the superstructure to the substructure.• To allow longitudinal/transverse movement of the superstructure.

- To allow rotation of beam/slab ends due to dead and live loading.

Types include roller, sliding plate, hinged, rocker and elastometric.

Bearing shelf	The shelf/surface upon which the bearing sits either directly or via a plinth. The bearing shelf is normally on the top of the abutment/pier.
Bracing	Components that provide longitudinal, lateral and/or torsional stiffness to the primary members and/or to the bridge deck.
Bridge deck	The component of a bridge superstructure that directly supports the running surface and traffic. It is normally defined as a secondary load bearing component because it transfers the traffic loads to the primary load bearing components, e.g. main beams, although the deck may be the primary load bearing element if it is a slab bridge, i.e. the slab is the bridge deck.
Buckle plate	Curved or buckled metal plate that is normally attached to the flanges of the main beams/girders to form the soffit of the bridge deck. It may be arched or suspended.
Cantilever	A structural component, normally a slab or beam, which has one unsupported (free) end and one supported (fixed or built in) end.
Cross head or capping beam	A component that sits on top of column piers. The purpose is to distribute loads to the piers and to provide a base for bearings.
Culvert construction forms	
<i>Pipe culvert</i>	A culvert with a circular or elliptical cross section.
<i>Box culvert</i>	A culvert with a rectangular or square cross-section that has rigid connections between the top and bottom slabs and the side walls. It may be single or multi cell.
<i>Portal or frame culvert</i>	A culvert with a rectangular or square cross-section that has rigid connections between the top slab and side walls.
<i>Slab culvert</i>	A culvert with a rectangular or square cross-section that does not have a rigid connection between the top slab and the side walls.
Foundation	A construction below ground level that supports piers and/or abutments. The purpose of the foundations is to provide a solid and stable base for the bridge and to distribute loads to the ground. Foundations for highway structures are normally spread (e.g. slab, strip) or piled.
Gabions	Mesh baskets filled with stones or other suitable fill that come in the form of boxes and mattresses and are used to retain earth and provide erosion protection.
Invert	The bottom, or lowest internal point, of a bridge or culvert when viewed in cross section. The invert is normally included on

inspection pro forma in order to check for scour and erosion in watercourses.

Joints Joints in the bridge construction that allow movement and/or are a feature of the construction form. Joints may be open (allow water/debris to pass through) or closed (do not allow water/debris to pass through).

Half joint Normally found on three-span beam and slab bridges, located at the points of contraflexure (i.e. at cross-sections of low bending and high shear forces) in the centre span. A half-joint includes bearings that allow rotation and sometimes longitudinal movement.

Hinge joint Normally found on some three-span beam and slab bridges and located at the points of contraflexure (i.e. at cross-section of low bending and high shear forces) in the centre span. A hinge joint allows rotation but not longitudinal movement. Also found in some bridge piers.

Parapets A wall/rail/fence that runs along the outside edges of the bridge deck, or retaining wall, parallel to the direction of traffic flow. The purpose of the parapet is to prevent users from accidentally falling off the bridge.

Pier Part of the substructure that provides intermediate support to the superstructure on multi-span bridges. Piers transfer loads to the ground/foundation and may be of column, wall or frame construction. A pier, as with the abutment, should provide adequate clearance between the superstructure and the obstacle crossed.

Retaining wall construction form

Cantilever Inverted T or L shaped structure (in cross section) where the vertical section of the wall is rigidly fixed to the horizontal foundation section and transfers horizontal loads to the foundation principally by bending action.

Gravity A wall which resists horizontal earth pressure through its own self-weight.

Embedded Similar to a cantilever retaining wall except there is no horizontal foundation component, instead stability is achieved through the embedded depth.

Revetment Material placed on the slope of the bank of a watercourse in order to provide protection against erosion. Revetments are associated with a bridge/culvert/retaining wall if they are provided for the sole purpose of protecting the structure. A revetment may include an apron at the toe of the slope if it is susceptible to scour.

Slab A two dimensional component that directly supports the running surface and traffic and, in many construction forms, is referred to as the bridge deck. Slabs are normally designed to support load in bending.

<i>Solid slab</i>	A solid slab with a homogeneous cross section.
<i>Voided slab</i>	A slab with voids in the cross section to reduce dead weight.
Spandrel	Normally the side walls to an arch, which support the fill. However could be used to describe columns or walls, which support the bridge deck on open-spandrel arches.
Troughing	Shaped component with a repeating trapezoidal pattern in cross section that normally spans between the longitudinal or transverse beams/girders and forms the soffit of the bridge deck. Sometimes troughing may span between abutments as the primary load bearing member.
Truss	A component built up from individual members, normally arranged and connected in a triangular/rectangular pattern, and consisting of a top chord, bottom chord and internal members.
<i>Truss bridge</i>	Trusses form the primary (main) longitudinal members.
<i>Through-truss bridge</i>	The longitudinal trusses are connected by top and bottom transverse beams and bracing, that forms a “cage” which the traffic passes through.
<i>Half through-truss bridge</i>	The longitudinal trusses are connected by bottom transverse beams and bracing but top beams/bracing is omitted because there would be insufficient headroom for traffic.
Waterproofing	A protective coating placed between the road construction and the bridge deck in order to protect the bridge deck from the ingress of water and harmful agents, e.g. chloride ions.

Other Definitions

Accommodation bridge	A bridge, or underpass, connecting two areas of land which were under common ownership but separated when a highway was built.
Accruals Accounting	A method of recording expenditure as it is incurred and assets as they are consumed regardless of when the cash is received or paid out.
Approval in Principle	The document which records the agreed basis and criteria for the detailed design or assessment of a highway structure as part of the Technical Approval process.
Assessment	See Structural Assessment.
Asset Management	A strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.
Transport Asset Management Plan	A plan for managing the transport asset base over a period of time in order to deliver the agreed Levels of Service and Performance Targets in the most cost effective way. This may be referred to as a Highway Asset Management Plan (HAMP) in other guidance documents and codes of practice.
Asset Management Regime	Comprises the organisational structure and business processes, asset management planning and work planning, and information management and systems that enable asset management to be effectively planned and delivered.
Asset Management System	The hardware and software that supports Asset Management practices and processes and stores the asset data and information.
Asset Valuation	The procedure used to calculate the asset value.
Asset Value	The calculated current monetary value of an asset or group of assets. It should be correctly referred to as the Net Asset Value, however it is normally shortened to Asset Value. Where the term Asset Value is used in this Code it should be interpreted as the Net Asset Value. Asset Value is synonymous with Depreciated Replacement Cost and Net Book Value.
Authority	A collective term used to refer to any owner of a highway structure, i.e. highway authorities and other owners. Also see owner.
Backlog	The monetary value of work required to close the gap between the actual performance provided by an asset and the current required performance.
Balance Sheet	A financial statement showing the assets and liabilities of an authority.

Bridge engineer	A chartered civil or structural engineer with appropriate experience in highway structures engineering and management.
Bridge manager	A chartered civil or structural engineer with appropriate experience in highway structures engineering and management to take the lead in advising the authority on the management of highway structures. The bridge manager is responsible for managing highway structures on a part, or all, of the highway network.
Bridge Management System	The hardware and software that supports highway structures management practices and processes and stores the inventory, condition and performance data. A framework for a Bridge Management System is described in Section 10.
Commuted Sum	A financial sum paid by the current owner of a structure to the new owner to cover all the future liabilities and costs involved in the upkeep and replacement of the structure from the time of transfer.
Critical Structure	A structure that has a load bearing capacity below those of others on a particular section of road.
Data	Numbers, words, symbols, pictures, etc. without context or meaning, i.e. data in a raw format.
Defects Correction Period	The period defined in a construction contract during which the contractor is responsible for making good defects that appear. The scope of defects the contractor is responsible for making good should be set out in the defects liability clause. The period usually commences upon practical completion of the works and runs for a specified time frame. The length of the Defects Liability Period should be specified in the contract. This is also referred to as the Period of Maintenance or Defects Liability Period.
Defects Liability Period	See Defects Correction Period.
Depreciation	The consumption of economic benefits embodied in an asset over its service life arising from use, ageing, deterioration or obsolescence.
Depreciated Replacement Cost/ Net Asset Value	The calculated current monetary value of an asset or group of assets, normally calculated as the Gross Replacement Cost minus accumulated depreciation and impairment. This is synonymous with Net Book Value.
Fit for Purpose	When a highway structure is managed in such a way that it meets the agreed Levels of Service for the route.
Generally Accepted Accounting Practice	An international accounting convention for preparing financial reports by private companies. These are customised in each country to comply with the national accounting standards.
Good Management Practice	A customer (outcome) focused asset management approach that seeks to deliver the required Levels of Service, minimise whole life costs, make optimum use of resources and provide a sustainable programme of work. The guidance and recommendations made in the Code align with accepted Good Management Practice.

Gross Replacement Cost/Gross Asset Value	The total cost of replacing a highway asset as part of the existing highway network.
Highway authority	A national or local authority as defined in Section 1 of the Highways Act 1980 as amended. Highway authorities include local authorities (unitary authorities, metropolitan and London boroughs and county councils), trunk road agencies and Transport for London.
Highway network	Collective term for publicly maintained facilities laid out for all types of user, and for the purpose of this guidance includes, but is not restricted to, roads, streets, footways, footpaths and cycle routes.
Highway Structures Stock	All highway structures owned by or the responsibility of an authority. Where numerous maintaining agents manage the structures on behalf of such a body, the term still relates to the sum of the structures.
Impairment	A reduction in Net Asset Value due to a sudden or unforeseen decrease in condition and/or performance of an asset compared to the previously assessed level which has not been recognised through depreciation.
Information	A collection of numbers, words, symbols, pictures, etc. that have meaning, i.e. information is data with context.
Inspector	A person competent by virtue of a combination of qualification, experience and training to undertake the specified inspection.
Inventory data	Information on each individual structure in the stock, including but not restricted to location, structural type, dimensions, construction information and records of use.
Knowledge	The understanding of information through assessment, analysis, etc, that provides a basis for decision making.
Level of Service	A statement of the performance of the asset in terms that the stakeholder can understand. They cover the condition of the asset and non-condition related demand aspirations, i.e. a representation of how the asset is performing in terms of both delivering the service to the stakeholder and maintaining its physical integrity at an appropriate level. Levels of Service typically cover condition, availability, accessibility, capacity, amenity, safety, environmental impact and social equity.
Lifecycle Plan	A considered strategy for managing an asset, or group of similar assets, from construction to disposal. A lifecycle plan should give due consideration to minimising costs and providing the required performance.
Occupation bridge	A bridge, or underpass, carrying a private road which pre-existed an intersecting highway.
Maintaining Agent	The organisation responsible for maintaining a group of highway structures on behalf of the owner.

Maintenance	A collective term used to cover all the activities and operations undertaken to manage and maintain a highway structure, e.g. inspection, assessment, renewal, upgrade etc. Section 5 divides maintenance into Regular, Programmed and Re-active and provides a description of the activities covered by each.
Monitoring	Observation or measurement repeated periodically or continuously over time.
Owner	A collective term used to refer to any owner of a highway structure, i.e. highway authorities and other owners. Also see authority.
Other owner	An owner of a highway structure who is not a highway authority. Other owners include Network Rail, BRB (Residualy), Environment Agency, British Waterways, London Underground Limited and private owners.
Performance Measure	A generic term used to describe a measure or indicator that reflects the condition and/or performance of an asset, e.g. Best Value Performance Indicators and other Performance Indicators.
Period of Maintenance	See Defects Liability Period.
Resource Accounting and Budgeting	An accounting procedure adopted by Central Government in 2001 that aims to provide a systematic link between an organisation's objectives, resources consumed and outcomes delivered.
Safe for Use	When a highway structure is managed in such a way that it does not pose a risk to public safety.
Stakeholder	An individual, group, body or organisation with a vested interest in the management of the transport network, e.g. authority/owner, public, users, community, customers, shareholders and businesses.
Statement of Accounts	A set of financial statements which present the financial performance and position of an authority during the accounting period covering its assets, liabilities, income and expenditure, cash flow, and any provisions for the future.
Stewardship	The management and care of highway structures on behalf of owners and the public.
Stock	See Highway Structures Stock.
Structural Assessment (or Assessment for short)	A process of confirming the adequacy of a structure to support specified loads and determining appropriate remedial actions if necessary. Assessment is carried out in accordance with national standards and generally involves detailed numerical calculations.
Structure File	A file for each structure or for a group of minor structures of similar design, which contains information considered appropriate for inspection and maintenance management. The file may be electronic and/or paper and the suggested contents are described in Section 9.

Structural Review	A review of an individual structure or group of structures, within the highway structures stock, to establish or confirm the validity of its latest assessment (or its original design, if there has been no subsequent assessment).
Substandard structure	A structure that does not meet the requirements of standards used in its assessment.
Technical Approval	The formal arrangement by which the Maintaining Authority agree the basis on which the structural design or assessment is to be carried out and includes a formal certification process at the end of design or assessment and completion of construction.
Technical Approval Authority	The organisation responsible for agreeing the Technical Approval on behalf of the owner.
Value management	Assessment and prioritisation of identified maintenance needs.
Value engineering	Development of optimal solutions for prioritised maintenance using option appraisal, whole life costing, scheme development, and synergies with other highway schemes.
Whole of Government Accounting	A central Government initiative to produce a comprehensive set of accounts from 2006-07 for the whole of the public sector covering central government departments, local government, agencies, NHS trusts and other public bodies in a style similar to the private sector following Generally Accepted Accounting Practice.
Workbank	All outstanding maintenance work on highway structures on a network.

Abbreviations

AIP	Approval in Principle
AM	Asset Management
APR	Annual Progress Report
BMS	Bridge Management System
BRE	Building Research Establishment Ltd
BVPI	Best Value Performance Indicator
Cadw	A Welsh word which means “to keep”
CAWR	The Control of Asbestos at Work Regulations
CDM	The Construction (Design and Management) Regulations
CIPFA	Chartered Institute of Public Finance and Accountancy
CPA	Comprehensive Performance Assessment
CSS	County Surveyors Society
DEFRA	Department of Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges
DTI	Department of Trade and Industry
EA	Environmental Agency
e-GIF	electronic-Government Interoperability Framework
FRS	Financial Reporting Standard
GAAP	Generally Accepted Accounting Practice
GIS	Geographical Information System
GPS	Geographical Positioning System
H&S	Health and Safety
LASAAC	Local Authority Scotland Accounting Advisory Committee
LUL	London Underground Limited
LoBEG	London Bridges Engineering Group

LIP	Local Implementation Plan
LTP	Local Transport Plan
MCDHW	Manual of Contract Documents for Highway Works
NRSWA	New Roads and Street Works Act
PAS	Publicly Available Specification
PI	Performance Indicator
RAM	Resource Accounting Manual
SORP	Standard of Recognised Practice
STGO	Special Type General Order
TA	Technical Approval
TAA	Technical Approval Authority
TAMP	Transport Asset Management Plan
TMA	Traffic Management Act
TRO	Traffic Regulation Order
RAB	Resource Accounting and Budgeting
WGA	Whole of Government Accounts
WLC	Whole Life Costing

Section 1

Introduction

This section introduces the Code of Practice, provides an overview of the current status of highway structures management in the UK and establishes the need for an overarching authoritative Code of Practice. The overall purpose, scope, objectives and status of the Code are presented, as is an overview of the asset management approach adopted by the Code. The different sections of the Code are summarised and guidance is provided on using the Code.

1.1 BACKGROUND

The Role of Highway Structures

- 1.1.1 It is widely recognised that a well managed transport infrastructure is vital to the economic stability, growth, and social well being of a country. Bridges and other highway structures are fundamental to the transport infrastructure because they form essential links in the highway network. It is not therefore in the public interest to allow highway structures to deteriorate in a way that compromises the functionality of the highway network, be it through restrictions or closures caused by unsafe structures or the disruption of traffic through poor planning of maintenance work.



Ownership and Management of Highway Structures

- 1.1.2 Highway structures represent a significant national investment, with most being publicly owned and many being prominent features in the local environment. In the UK the management of highway structures is undertaken by a variety of owners/agencies, e.g. local authorities, trunk road agencies, Network Rail, BRB (Residuary) Ltd, Environment Agency, British Waterways, London Underground, Transport for London and many private owners. In the Code they are collectively referred to as 'owner' or 'authority' as appropriate.
- 1.1.3 There is a statutory obligation on highway authorities to maintain the public highway [*Highways Act 1980; 1*]. The obligation embraces the two essential functions of *Safe for Use* and *Fit for Purpose*. The two functions are not the same:

1. *Safe for Use* requires a highway structure to be managed in such a way that it does not pose an unacceptable risk to public safety.
 2. *Fit for Purpose* requires a highway structure to be managed in such a way that it remains available for use by traffic permitted for the route.
- 1.1.4 In the UK an overarching authoritative document was not hitherto available that described how these obligations should be met and what management practices should be adopted. This has resulted in the development of a wide range of management practices for highway structures, which differ considerably in their objectives, approach, standards and processes. The extent to which practices have advanced beyond those needed to meet the legal minimum requirements, for example the use of whole life costing and risk assessments, has been variable. In the extreme, only minimal management involving work essential for maintaining the safety of structures has been applied. Most authorities use a short term reactive approach to maintenance; however, in recent years a small number of authorities have started adopting a formal asset management approach. Asset management takes a strategic, longer term and integrated approach for the management of transport infrastructure assets across an authority. The Code embraces asset management principles in developing the guidance for the management of highway structures.

Funding for Maintenance of Highway Structures

- 1.1.5 The County Surveyors Society's (CSS) report *Funding for Bridge Maintenance* [2] argued that the condition of the bridge stock owned by local highway authorities has been gradually declining due to long term underfunding of maintenance. This is due in part to the absence of a Code of Practice that specifies appropriate standards of maintenance. As a result, bridge managers have found it difficult to justify appropriate levels of funding for the maintenance of highway structures in an increasingly competitive environment, and have been unable to secure a fair proportion of the limited budgets available for transport.
- 1.1.6 The consequences of not securing appropriate funding include:
1. An inadequate *Regular Maintenance* regime, i.e. inspection, testing, routine and preventative maintenance. The result is that some deterioration may progress unchecked which, in the longer term, can increase the risk of accidents and lead to unreliable services and a poor environment.
 2. An insufficient amount of *Programmed Maintenance*, e.g. component renewal and structural repairs. *Programmed Maintenance* represents good long term value if carried out on time; however maintenance interventions are frequently later than desirable and represent a poor return on the investment made.
 3. An increasing backlog of maintenance work resulting in a greater proportion of the available funding being used for *Reactive Maintenance* in order to maintain safety and serviceability.
- 1.1.7 The need to quantify and justify the level of funding required to manage and maintain (or improve) the national stock of highway structures, in a manner that represents good long term value, has highlighted the importance of adopting a

formal asset management approach as described in the *Framework for Highway Asset Management* [3], *PAS 55-1 Asset Management* [4] and the *International Infrastructure Management Manual* [5].

Recognition of the Need for Appropriate Maintenance

- 1.1.8 The need for appropriate levels of maintenance has been recognised in the Government's policy documents:
1. *Transport 2010: The 10 Year Plan* [6]
 2. *The Future of Transport: A network for 2030* [7].
- 1.1.9 The importance of maintenance has also been recognised in *Scotland's Transport Future* [8] and *The Mayor's Transport Strategy* [9].
- 1.1.10 Some funding has been identified in *Transport 2010: The 10 Year Plan* [6] to help bring the highway structures stock to a good state of repair. Whether or not this is adequate is difficult to determine given current management practices. Implementing the approach and processes described in this Code will enable authorities to identify the appropriate level of funding for highway structures.
- 1.1.11 Recent Government policy objectives contained in various documents such as *Full Guidance on Local Transport Plans: Second edition* [10], the Best Value legislation [11], *The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002* [12], the introduction of Resource Accounting and Budgeting [13, 14, 15], Asset Valuation [16] and *The Prudential Code* [17] have profound implications in terms of how the maintenance and renewal of highway infrastructure will be funded and managed in future years. This Code aims to assist harmonisation and improvement of current practice of highway structures management and alignment with the requirements of new legislation.

Management Practices

- 1.1.12 Highway authorities and other owners have hitherto applied a wide range of management practices. Current practices are briefly summarised below, followed by a description of what constitutes Good Management Practice.

Current Management Practice

- 1.1.13 On some networks, or parts of networks, a minimum of inspection and maintenance that is sufficient only to meet the legal obligation for safety and accommodating the traffic is applied. This approach allows the condition of structures to deteriorate over time and may consist only of reactive maintenance and repair to the extent that funding and circumstances allow. This approach represents the bare minimum of maintenance action and results in increased risks to safety and network availability, a growing maintenance backlog and a build-up of unacceptable restrictions or substandard structures because structural deficiencies are not addressed on time.
- 1.1.14 Currently, most authorities adopt a short term reactive approach for the maintenance of highway structures. This approach adequately manages safety and serviceability by identifying and carrying out the maintenance work needed but may not necessarily provide good long term value for the money spent and

it is uncertain if it will achieve the agreed medium to long term goals and objectives of the authority. This approach makes it difficult to estimate and justify long term funding requirements and as a result it has been argued that the condition of the UK's local authority highway structures is gradually declining [*Funding for Bridge Maintenance*; 2]. At best the approach may maintain the current condition and performance of a stock of highway structures but is unlikely to address any maintenance backlog or deliver long term value for money. In some cases, this approach may allow the backlog of maintenance to increase, condition and performance to deteriorate and whole life costs to increase. Highway authorities or other owners currently using a short term reactive approach should plan their progress towards a long term asset management approach, referred to here as Good Management Practice and discussed below.

Good Management Practice

1.1.15 This Code seeks to promote the implementation of recognised Good Management Practice which is based on a customer (outcome) focused asset management approach that seeks to deliver the required Levels of Service, minimise whole life costs, make optimum use of resources and provide a sustainable programme of work (see Section 1.4). It will also help authorities in implementing current and emerging Government policy requirements.

1.1.16 Authorities should aim to fully implement the Good Management Practice embodied in the Code in a phased manner. Implementation of the Code will encourage the adoption of a common framework and consistent approach across the national network.

1.2 PURPOSE AND SCOPE

Purpose of the Code

1.2.1 The purpose of the Code is to provide authoritative guidance on highway structures stewardship duties and the development of recognised Good Management Practice. The Code seeks to promote a degree of management consistency that, while allowing some individual flexibility, will form the framework for harmonisation and coordination of practices across the UK. Consistency in practice will assist bridge engineers and managers to adopt a common approach, align and focus development needs, share experience and strengthen the argument for appropriate funding for highway structures maintenance and management.

1.2.2 The Code has been developed around an asset management approach which illustrates how bridge management activities can be brought together in a systematic and holistic framework. The framework assists bridge managers to compare their current practice against recommended Good Management Practice, determine any shortfalls in practice, and identify how they should prioritise their needs and progress towards Good Management Practice. The implementation of the Code is expected to deliver the agreed network Levels of Service, defined in the Strategic Transport Plan (e.g. LTP or LIP), to the public in the most cost effective manner.

Objectives of the Code

- 1.2.3 The objectives of this Code are to encourage and assist highway authorities and other owners to:
1. Implement Good Management Practice that is appropriate to local circumstances, the structure type and the function a structure provides. Practices should embrace:
 - Adequate inspection and maintenance programmes that avoid the accumulation of backlog and enable sustainable work programmes over the longer term.
 - Risk management and whole life costing procedures in the determination of local technical and operational standards and in the prioritisation of works.
 - Government policy objectives of Resource Accounting and Budgeting, integrated transport and sustainability.
 2. Harmonise policies, procedures and practices in order to provide a more consistent approach to highway structures management throughout the UK whilst allowing flexibility to take account of local factors, priorities and choices.
 3. Coordinate approaches to improve highway structures management practices and the development of the supporting processes and tools.
 4. Share their experiences and examples of Good Management Practice.
- 1.2.4 Subsidiary aims of the Code are to:
1. Identify and define the legal and government policy framework and socio-economic context in which bridge managers operate in meeting the expectations of a range of stakeholders.
 2. Provide an authoritative account of inspection and maintenance management of highway structures encompassing current national and international best practice.
 3. Be easy to understand and implement by a wide range of users, primarily bridge managers but also inspectors, engineers, designers and planners.
 4. Provide standard definitions for the different highway structures and give a glossary of terms relevant to highway structures management.

Scope of the Code

- 1.2.5 This Code covers all aspects of highway structures management, except for the design of new structures for which reference should be made to existing codes and standards.



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1.2.6 The recommendations have been drawn up specifically for highway structures associated with the adopted road network. In addition the general principles apply to structures associated with all other highways that are used by the public, e.g. segregated footpaths and cycle routes, and the Public Right of Way network. The types of highway structure covered by the Code are those within the boundaries of the highway or which otherwise materially affect it and include:

1. Bridges, footbridges, cycleway bridges, bridleway bridges, accommodation bridges, occupation bridges, subways, underpasses and culverts.
2. Retaining walls.
3. Sign/signal gantries.
4. Cantilever road signs.
5. Tunnels.

1.2.7 The term 'highway structures' is used throughout the Code to refer collectively to all of the above structure types.

1.2.8 Some of the guidance provided in Section 3 (*Asset Management Planning*) and Section 4 (*Financial Planning and Resource Accounting*) is equally applicable to all highway infrastructure assets. It is essential that an integrated approach is taken to highway asset management and financial planning across all highway assets. Bridge managers are encouraged to share this guidance with their colleagues who manage roads, footpaths, cycle routes, lighting, street furniture, traffic management systems etc. and use it as a basis to promote discussion and integrated working.

1.2.9 The principles and processes described are generally applicable within the UK but, where the specific government policy and legal context is relevant, the context referred to is that in England. Where necessary, the national variations relevant in Wales, Scotland and Northern Ireland are also referenced.

1.3 STATUS OF THE CODE

1.3.1 The Code is published under the aegis of the UK Bridges Board with the endorsement of the UK Roads Liaison Group.

- 1.3.2 It is important that a consistent approach is followed for the management of all highway asset types, such that the overall performance requirements for the transport infrastructure are achieved in an optimal and balanced way. In this regard, this Code should be used as a companion to the following Codes of Practice:
1. *Well-Maintained Highways: Code of Practice for Highway Management* [18]
 2. *Well-Lit Highways: Code of Practice for Highway Lighting Management* [19]
- 1.3.3 The recommendations of this Code are not explicitly mandatory on owners of highway structures. However, in cases of claims or legal action, it is likely that the contents of the Code may be treated as a relevant consideration, as it is deemed to represent accepted good practice. In view of this, those who elect, in the light of local circumstances, to adopt policies, procedures or standards differing from those suggested by the Code, should identify these departures together with the reasoning for this.
- 1.3.4 It is recognised that affordability and local circumstances can impose constraints on implementing certain recommendations in the Code. The Code offers a degree of flexibility by:
1. Setting out the basic requirements for Good Management Practice in a goal setting rather than a prescriptive way. Recommending processes and procedures for meeting the requirements which are based on sound engineering and asset management practices.
 2. Describing the principles that underpin the processes and procedures presented. This enables alternative, and possibly more cost effective and locally suitable, practices to be developed provided the underlying principles are adhered to and the reasons for departure from the Code are fully documented.
 3. Providing a framework for reviewing, prioritising and planning the implementation of the recommendations in the Code in a phased manner. This allows bridge managers to customise implementation to suit available resources and local priorities while taking account of any national initiatives or requirements. Implementation of practices to meet safety and other statutory obligations should take precedence over other recommended actions.
- 1.3.5 The Code makes reference to other complementary publications including:
1. *Framework for Highway Asset Management* [3]
 2. *PAS 55-1 Asset Management* [4]
 3. *International Infrastructure Management Manual* [5]
 4. *Transport 2010: The 10 Year Plan* [6].
 5. *The Future of Transport: a network for 2030* [7].
 6. *Full Guidance on Local Transport Plans: Second edition* [10]
 7. *Local Government Act 1991* [11]

8. *The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002* [12]
9. *Scotland's Transport Future* [8]
10. London - *The Mayor's Transport Strategy* [9].

1.3.6 The relationship of this Code with some of the aforementioned documents is illustrated in Figure 1.1.

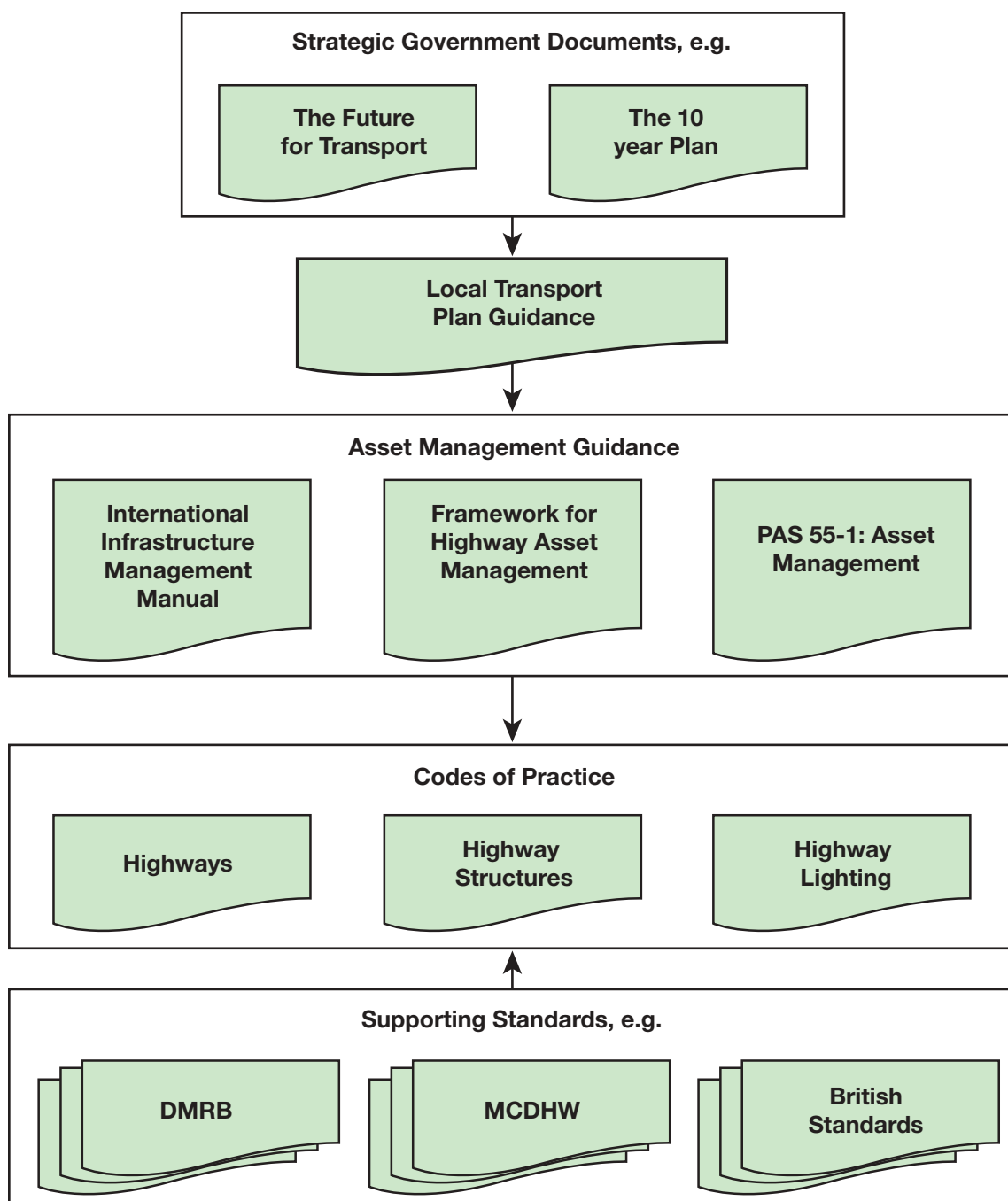


Figure 1.1: Relationship of documents relevant to highway structures management

1.4 OVERVIEW OF ASSET MANAGEMENT

- 1.4.1 The Code emphasises the need for an asset management approach that gives due consideration to the wider highway network and local environment in which structures exist. Asset management is defined in the *Framework for Highway Asset Management* [3] as:

Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.

- 1.4.2 Full application of asset management involves the combination of engineering, management and financial processes optimally over the long term, so the asset maintains its value and provides the required Levels of Service in the most economic and sustainable way. The benefits provided by asset management include:

1. Linking management of assets with long term strategic business objectives and goals.
2. Taking an integrated approach to planning and decision-making at all management levels and across asset types.
3. Treating the transport infrastructure as a 'networked system' such that all assets and their interfaces are managed in an integrated and balanced way to achieve the required performance.
4. Taking a lifecycle approach that covers construction, operation, maintenance, disposal and replacement of an asset with a view to minimising whole life costs or maximising whole life value.
5. Identifying and managing the risks associated with asset failure and service loss due to inadequate performance of assets.
6. Checking that the asset base is preserved and replenished in a sustainable and cost effective way without imposing an undue burden on future generations.
7. Measuring performance of the assets and of the management functions and providing feedback to facilitate continual improvement.

- 1.4.3 Section 3 (*Asset Management Planning*) provides an overview of a framework for asset management of highway structures. The overall concept is that:

1. An authority's strategic objectives and goals set the longer-term direction and performance targets for the transport system as a whole and correspondingly for the stock of highway structures.
2. The strategic objectives and goals guide long term and short term planning and address the purpose of the structure, needs for maintenance and priorities by region, area, route and structure type.
3. Short term plans are implemented through engineering processes, such as inspection, evaluation, assessment, scheme design and implementation.

4. Audit and reporting processes, through carefully selected performance measures, provide a feedback loop to the planning process to enable continual enhancement of the management process to yield improvements.
- 1.4.4 Asset management enables the bridge manager to plan and carry out works on highway structures that are appropriately targeted and contribute towards the strategic objectives and goals for the highway network in the most cost effective manner while bearing in mind responsibilities to the other parties.

1.5 USING THE CODE

- 1.5.1 The Code contains a large body of information on highway structures management. Authorities should adopt a structured approach to studying, understanding, implementing and using this information. Such an approach is described in Section 11 (*Implementation of the Code*) and is summarised below.

Getting started

- 1.5.2 The “Getting Started” phase should seek to develop a sound understanding of the Code and may include the following activities:
1. Examine the Code. Individual sections of the Code may be studied by different personnel as appropriate but the bridge manager should maintain an overview of the whole Code.
 2. Attend regional or national events planned for dissemination of the Code.
 3. Organise and hold an internal workshop to disseminate the guidance and key requirements given in the Code to all relevant personnel within the Authority, including senior management.
 4. Identify and assign responsibilities for the implementation of the Code and plan the way forward.
- 1.5.3 On completion of these initial activities an authority should be in a suitable position to develop a plan for the implementation of the Code.

Recommendations

- 1.5.4 The Code makes a number of recommendations for implementing Good Management Practice for highway structures and these are presented at the end of relevant sections of the Code and listed in full in Section 11. The recommendations are supported by specific actions that should be undertaken to achieve these. The actions are presented in a tabular format at the end of each section and listed in full in Section 11.
- 1.5.5 The actions are classified under three milestones in order to assist implementation of the Code as discussed below.

Implementation of the Code

- 1.5.6 The Code should be implemented by developing a formal implementation plan. The plan should be appropriate to the size and character of the stock of highway structures, existing constraints and local circumstances. Section 11

provides guidance on the process that should be used to develop an implementation plan.

- 1.5.7 To assist the development of an implementation plan, and the progression towards Good Management Practice, the recommended actions are presented under three milestones, where:
1. **Milestone One** is intended broadly to include the adoption of processes necessary to provide highway structures that are *safe to use, inspect and maintain*.
 2. **Milestone Two** encompasses Milestone One and is also intended broadly to include the adoption of additional processes necessary to provide highway structures that are *fit for purpose* and meet Government requirements. Milestone Two represents an interim step on the progression towards Milestone Three.
 3. **Milestone Three** encompasses Milestones One and Two and additionally requires the adoption of processes necessary to deliver the agreed Levels of Service (and Performance Targets) at minimum whole life costs, and to align with current and emerging Government policy objectives. This represents the full implementation of the Good Management Practice set out in this Code.
- 1.5.8 Section 11 describes how the Milestones, and their associated actions, should be used for the development of an implementation plan. The process includes determining current practice, a gap analysis and development of the implementation plan and on-going review of implementation.

Format of the Sections

- 1.5.9 The Code is in eleven sections. A brief summary of the contents and objectives is included at the start of each section. Within Sections 3 to 10, the text is generally structured as follows:
1. **Purpose (Why are we doing it?)** - the overall purpose of the content of the section in relation to the management of highway structures.
 2. **Requirements (What we want to achieve?)** - the basic requirements that the authorities should seek to achieve.
 3. **Basis and Principles (Why do we do it in this way?)** - an explanation of the basis and principles that guide the development of an appropriate process(es) to deliver the requirements.
 4. **Process (How do we do it?)** – a description of the process, or processes, that may be used for achieving the requirements, including appropriate recommendations, complementary guidance and references.
 5. **Recommendations (What should we do?)** – a list of the recommendations and supporting actions derived from the section. The purpose is to assist the determination of gaps in current practice and to establish priorities for implementing Good Management Practice.

Finding what you need

1.5.10 The Code provides guidance on a wide range of issues involved in highway structures management. Each section deals with a specific area of highway structures management and the relationships between the sections are shown in Figure 1.4.

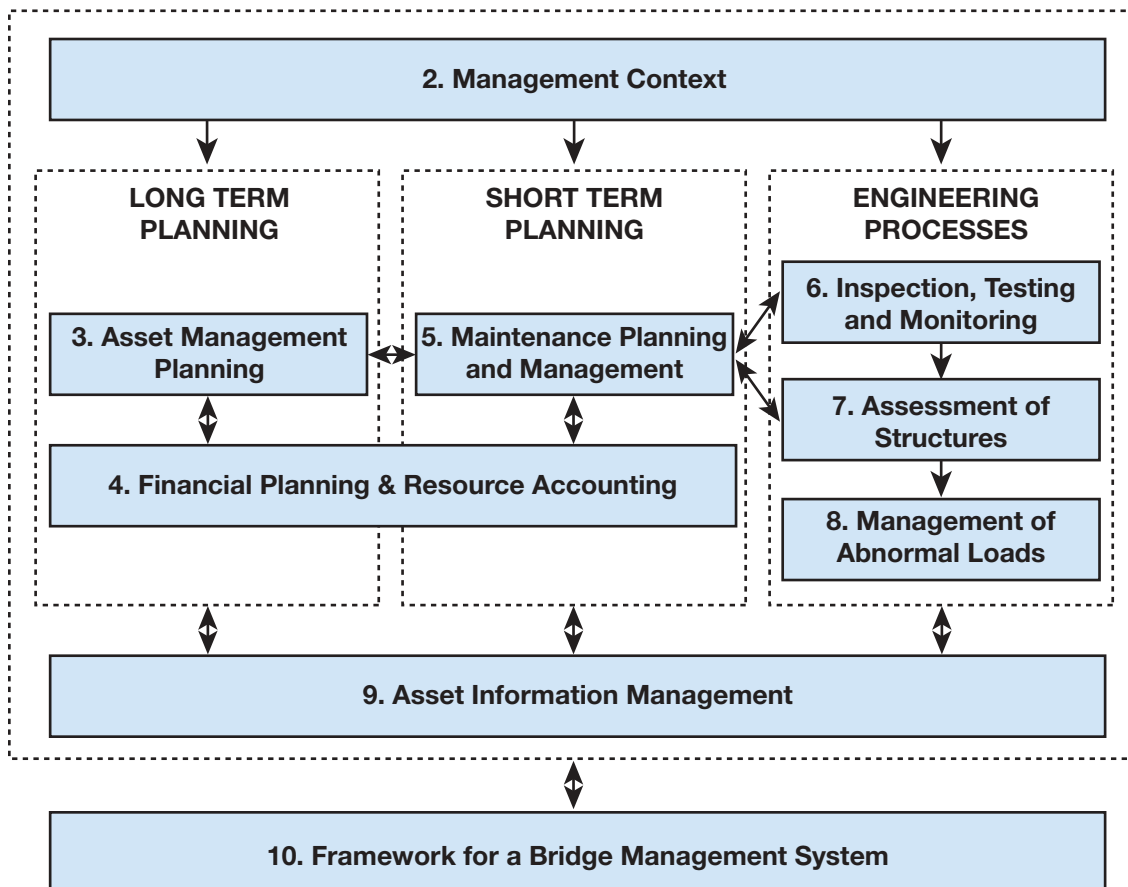


Figure 1.4: Sections in the Code

1.5.11 Figure 1.4 illustrates how Sections 2 to 9 of the Code should be supported by an appropriate Bridge Management System (Section 10). Table 1.1 provides an overview of each section, explains the relevance of each section to the management of highway structures and summarises the key guidance provided.

Table 1.1 - Sections of the Code	
Section	Summary of purpose and content of each section
1. Introduction	This section is intended to assist bridge managers in conveying the importance of the Code to others thereby providing justification for adopting the Code. It provides an introduction to the role of and need for the Code, describes the purpose, objectives, scope and status of the Code and provides an overview of the asset management approach adopted by the Code.
2. Management Context	It is essential for bridge managers to be knowledgeable and well-informed about the overall management context and environment in which they have to operate. This section provides information on the criteria and requirements that bridge managers should take account of, e.g. statutory duties and powers, socio-economic and political considerations, health and safety and environmental considerations.
3. Asset Management Planning	Asset management provides a stakeholder/outcome focused, formal and holistic approach to the management of assets. Overview of an asset management framework for transport infrastructure is presented along with an asset management planning process for highway structures. The suggested content of a Transport Asset Management Plan is described so bridge managers can understand their contribution to the plan.
4. Financial Planning and Resource Accounting	The purpose of financial planning is to secure funding, support budget setting and ensure the available funding is appropriately targeted and effectively spent. The purpose of resource accounting is to reflect the full cost of ownership and use of highway structures in delivering transport services. Different levels of financial planning, from short term budgets to long term Transport Asset Management Plans are described. The principles and requirements of Resource Accounting are presented and the asset valuation process is summarised.
5. Maintenance Planning and Management	The purpose of maintenance planning and management is to enable the bridge manager to develop and implement cost effective and sustainable maintenance plans for highway structures that support the safe operation of the network while delivering the required levels of performance. A formalised process for maintenance planning and management is provided that includes identification of needs, preparation of a workbank, value management, value engineering, developing a forward work plan and work scheduling.
6. Inspection, Testing and Monitoring	The overall purpose of inspection, testing and monitoring is to determine if the highway structures stock is safe for use and fit for purpose and to provide the data, including historical, required to support Good Management Practice. The inspection, testing and monitoring regimes and techniques necessary to provide this support are described.
7. Assessment of Structures	The purpose of the assessment is to determine the ability of the structure to carry the loads which are imposed upon it and which may reasonably be expected to be imposed upon it in the foreseeable future. This provides important information for managing the safety and serviceability of highway structures. A regime for structural review and reassessment is recommended and guidance is given on the assessment process.

Table 1.1 - Sections of the Code (continued)	
8. Management of Abnormal Loads	The purpose of management of abnormal loads is to control the movement of large and heavy vehicles that use the road network. Key features of basic and advanced systems for the management of abnormal vehicle movements are presented so that individual authorities can adopt a system that best suits their needs. Guidance is given on the approach to be used for managing General Order and Special Order vehicle movements.
9. Asset Information Management	The purpose of information management is to provide accurate and up-to-date information to support the effective management of highway structures. This section describes an appropriate asset information management process and identifies the data required to support Good Management Practice.
10. Framework for a BMS	This section provides a generic framework and specifications for a BMS that supports the Good Management Practice set out in the Code. This seeks to support authorities in the development and/or procurement of a BMS.
11. Implementation of the Code	The purpose of this section is to assist authorities in the implementation of the Good Management Practice set out in the Code. This is achieved by providing a simple process that can be used to identify the gaps in current practice, prioritise the needs, assess resource needs and costs, and plan implementation.

1.6 FUTURE REVISIONS

- 1.6.1 It is recognised that parts of the guidance and information contained in this Code may become out of date with time, while some of the recommendations may need to be reviewed and updated in the light of experience and new knowledge. It is intended that the Code is revised and enhanced from time to time as necessary.

1.7 REFERENCES FOR SECTION 1

1. *Highways Act 1980*, HMSO.
2. *Funding for Bridge Maintenance*, County Surveyors Society, February 2000.
3. *Framework for Highway Asset Management*, County Surveyors Society, April 2004.
4. *PAS 55-1 Asset Management: Part 1: Specification for the optimized management of physical infrastructure assets*, The Institution of Asset Management and BSI, 2004.
5. *International Infrastructure Management Manual*, UK Edition, 2003.
6. *Transport 2010: The 10 Year Plan*, DETR, July 2000, ISBN 1 85112 413 6.
7. *The Future of Transport: a network for 2030*, Department for Transport, July 2004, ISBN 0 10 162342 9.

8. *Scotland's Transport Future*, Scottish Executive, document available on website www.scotland.gov.uk/library5/transport.
9. The Mayor's Transport Strategy, document available on website www.london.gov.uk/mayor/strategies/transport/trans_strat.jsp
10. *Full Guidance on Local Transport Plans: Second edition*, Department for Transport, December 2004.
11. *Local Government Act 1999*, HMSO.
12. *The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002*, Statutory Instrument: 2002 No 305 Local Government, England and Wales, HMSO.
13. *Managing Resources: Analysing Resource Accounts: User Guide*, HM Treasury, 2001.
14. *Managing Resources: Implementing resource based financial management*, HM Treasury, September 2002.
15. *HM Treasury: Resource Accounting Manual*, www.resource-accounting.gov.uk
16. *Guidance Document for Highway Infrastructure Asset Valuation*, County Surveyors Society, The Stationery Office, July 2005.
17. *The Prudential Code for Capital Finance in Local Authorities*, CIPFA, 2003.
18. *Well-Maintained Highways: Code of Practice for Highway Management*, The Stationery Office, July 2005.
19. *Well-Lit Highways: Code of Practice for Highway Lighting Management*, ISBN 0 11552 632 3, The Stationery Office, November 2004.

Section 2

Management Context

This section provides background information and guidance on the overall management context and environment in which bridge managers have to operate. Guidance is included on competence and training, Government transport policy, legal and procedural requirements, Health and Safety requirements, environmental requirements, sustainability requirements, stakeholder consultation and interaction with other owners. Guidance is also given on interpretation of relevant legislation. However in certain circumstances interpretation may be case specific and legal advice should be sought for clarification in all cases.

2.1 GENERAL

- 2.1.1 The principal requirements placed on authorities and bridge managers, as defined in this Code, are to provide highway structures that are safe for use, fit for purpose and managed in accordance with good practice. In meeting these requirements bridge managers should give due consideration, based on appropriate knowledge and understanding, to the overall management context and environment in which they have to operate.



Atkins

- 2.1.2 Authorities should establish a process for compiling, storing and maintaining information on the overall management context and environment in which their bridge managers have to operate. This process should align with and be complementary to other similar processes used by the authority (e.g. for roads and property), or the authority may have one process to cover all highway, and other similar, assets. The process should be documented and have a mechanism for keeping relevant staff informed of changes, amendments, updates etc. All the management context information should be held in a readily accessible format, e.g. electronic folders/documents and/or hard copies.
- 2.1.3 The guidance provided in this Code is based on the legislation, practice and requirements in England unless otherwise stated. Where necessary, supplementary paragraphs are provided at the end of a sub-section to explain the legislation, practice and requirements in Wales, Scotland and Northern Ireland and for other owners, e.g. Network Rail, British Waterways and London Underground Limited (LUL).

2.1.4 The Code will be updated at regular intervals. However, the relevant legislation, practice and requirements are constantly changing (in particular Government transport policy and legislation) and need to be verified before use. There are a number of useful websites referenced in Appendix A which provide up-to-date reference material on Environmental Legislation, also The Stationery Office (see Appendix B) provides an on-line updating service. Legal processes should only be undertaken following appropriate legal advice.

2.2 COMPETENCE AND TRAINING

2.2.1 A basic premise of the Code is that highway structures management (including maintenance planning management and structural review and assessment) is carried out by suitably qualified and experienced civil or structural engineers and on-site work (including inspections, testing and maintenance) is carried out by appropriately qualified, trained and experienced personnel.

2.2.2 To assist progress towards the Good Management Practice described in the Code, a programme of Continuing Professional Development (CPD) and training for bridge managers, engineers, inspectors and other staff should be provided to enable them to understand and implement the processes described in the Code. It is recommended that agents and contractors are required to demonstrate that their personnel are adequately trained and competent for the work they undertake in relation to highway structures.

2.3 GOVERNMENT TRANSPORT POLICY AND PLANS

2.3.1 In England, the majority of funding available for the maintenance of local authority highway structures is allocated by the Department for Transport (DfT) through the Local Transport Plan (LTP) process as a capital allocation, which is not ring-fenced. This is supplemented to varying degrees by revenue budget provisions made directly by the local authority. The London equivalent of the LTP is the Local Implementation Plan (LIP).

2.3.2 The LTP process aims to deliver a five-year discrete programme of targeted transport improvements and maintenance that align with and seek to achieve a local authority's long-term transport strategy. The DfT has provided guidance on the preparation of the LTP to cover 2006/07 to 2010/11 in *Full Guidance on Local Transport Plans – Second edition, 2004* [1], and sets out particular national policies that need to be followed. Local policies need to be aligned with these policies in order to obtain a good assessment of the LTP and therefore an adequate capital allocation to deliver the plan. Transport for London has provided guidance on the preparation of the LIP in *Local Implementation Plan Guidance* [2].

2.3.3 The LTP guidance [1] states that in future the strategy for the maintenance of highway structures will need to be developed to suit the five-year “planning guideline” for capital allocations published by the DfT. Bridge managers are expected to achieve value for money through asset management and to make use of other methods for improving efficiency, such as the procurement savings highlighted by the Government's *Gershon Efficiency Review* [3].

2.3.4 Each year an annual progress report (APR) is submitted by an authority to allow comparison of actual progress against the original LTP proposals. This includes providing certain information on the maintenance of highway structures, which is used to determine the capital allocations for the following year. It is possible to amend the LTP through an APR, but the DfT does not

encourage this as they consider that one of the benefits of the process is the concept of continuity and a long-term approach. Detailed guidance on the production of APRs is given each year by the DfT [4].

- 2.3.5 In the first LTP round (2001/02 to 2005/06), there was scope within the APR for supplementary bids. However, in the second LTP round (2006/07 to 2010/11) the DfT, at present, only consider supplementary bids if they relate to emergency capital works that are essential for the safe operation of existing infrastructure.

Local Policies and Plans

- 2.3.6 Highway structure maintenance policies and strategies may be influenced by other local policies. It may be possible to secure further funding for highway structure maintenance if works can be combined with local strategies such as EU regeneration projects, local development initiatives, market town improvements, etc.
- 2.3.7 The LTP may also include integrated transport schemes and major schemes and it would be good practice to include appropriate highway structure maintenance projects with these schemes. The benefits gained, or savings made, from this coordinated approach may justify part, or complete, funding of these highway structure maintenance projects from the transport/major schemes budget.
- 2.3.8 The Local Government Act 2003 [5] introduced the concept of “prudential borrowing”, which allows local authorities to raise money on the open market provided it is for capital projects, they can afford to repay the sum and it has a limited effect on the Council Tax bill. Some local authorities are using prudential borrowing to fund the reduction of the backlog of outstanding highway maintenance.

National Variations

- 2.3.9 Funding for local roads in Wales and Scotland, both capital and revenue, is provided through the overall local government finance settlement. This funding is not ring-fenced and it is up to each council to decide the priority of local roads and structures amongst its other spending plans. It is therefore essential to be able to demonstrate and justify the need for highway structures funding, and the implications of underfunding, when competing against other demands for funding.
- 2.3.10 Funding for all roads in Northern Ireland is allocated in accordance with the Government’s Priorities and Spending Plans in Northern Ireland. This is guided by the Regional Transportation Strategy for Northern Ireland 2002-2012 (RTS), (www.drdni.gov.uk/DRDwww_TransportationPlanning/), which provides the strategic direction for Roads Service. Priorities are set in line with the requirements of the RTS and the bridge-strengthening programme.

2.4 BEST VALUE LEGISLATION

- 2.4.1 The Local Government Act 1999 [6] requires local authorities in England and Wales to look at the way they deliver services to the public and has placed on them a “Best Value” duty to improve the economy, effectiveness and efficiency of service provision. They are required to publish annual Performance Plans, which report the measures being taken to deliver improvements in the outcomes for local people and to record progress in delivering these outcomes.

- 2.4.2 Initially authorities were required to review all their functions on a five-year cycle with the reviews being based on the four Cs of Challenge, Compare, Consult and Compete. This was subsequently revoked by *Statutory Instrument 2002 No 305 "Local Government England and Wales: The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002"* [7]. Whilst there is still a statutory duty for local authorities to review their functions, it is now expected that reviews will be focussed on priority areas for improvement arising out of their Comprehensive Performance Assessments (CPAs) or other considerations. CPAs, which are based on service and corporate judgements taking account of authorities' performance and their prospects for improvement, were introduced to identify performance strengths and weaknesses and to provide a basis for the improvement planning which the duty of Best Value confers.
- 2.4.3 Reviews have been undertaken of most highway maintenance services and some have included highway structures, although the Best Value initiative has not had as much an impact as it should have had on many bridge managers. A suite of highway structure performance measures, jointly developed by the CSS and the Highway Agency, were published in February 2005 [8] and are summarised in Section 3 (*Asset Management Planning*). The highway structure performance measures, as with all other performance measures, are intended to form a basis for monitoring, auditing, comparison and improvement of performance, as originally conceived by CSS Best Value Groups.
- 2.4.4 Best Value reviews are now seen as only one way of improving performance and as a consequence many bridge managers are unlikely to carry out a formal review in the future. However the requirement for a continuous improvement in performance has not been relaxed. Therefore bridge managers need to examine their service on a regular basis in order to see how it can be improved. The principles of Best Value reviews still provide a good framework for carrying this out.

National Variations

- 2.4.5 In Scotland, the Local Government in Scotland Act 2003 [9] introduced Best Value principles. The legislation is less prescriptive than the English legislation but quotes similar criteria for achieving Best Value. Statutory requirements for Best Value performance plans and reviews have not been included.
- 2.4.6 The Local Government (Best Value) Act (Northern Ireland) 2002 [10] introduces Best Value in a very similar way to the Scotland Act with limited prescription. However, local authorities in Northern Ireland do not have responsibilities for highways or highway structures. These assets are the responsibility of the Department of Regional Development for Northern Ireland and the responsibility is discharged by the Roads Service, an Executive Agency within the Department.

2.5 RESOURCE ACCOUNTING REQUIREMENTS

- 2.5.1 The UK Government introduced new Resource Accounting and Budgeting (RAB) procedures for all Government Departments from 2001-02. RAB will be extended to local authorities by 2006/07 as part of the introduction of Whole of Government Accounts (WGA). The objectives of RAB and WGA are to promote greater accountability, transparency and improved stewardship of public finances. The introduction of RAB will have a profound impact on how highway structure maintenance is financed and managed. This subject is dealt with in greater detail in Section 4 (*Financial Planning and Resource Accounting*).

2.6 LEGAL AND PROCEDURAL REQUIREMENTS

- 2.6.1 The majority of highway maintenance, including structures maintenance, is based upon statutory duties and powers contained in legislation as supported by legal precedent. Even in the absence of specific reference to duties and powers, authorities have a general duty of care to users and the community to maintain the highway in a state that is safe for use and fit for purpose. These principles should be applied to all decisions affecting policy, priority programming and implementation of works on highway structures.
- 2.6.2 The Highways Act 1980 [11] sets out the main duties of highway authorities in England and Wales. In particular Section 41 imposes a duty to maintain highways that are maintainable at public expense. Where a highway passes over a bridge, Section 328(2) vests the bridge as part of the highway and the normal duty to maintain under Section 41 of the 1980 Act applies under these circumstances. However this does not preclude bridges under highways being in private ownership and rightly the responsibility of the private owner, see paragraphs 2.6.4 to 2.6.6. Retaining walls which abut the highway should also be taken as part of the highway and should be dealt with similarly to bridges. Guidance on the determination of ownership of and responsibility for maintenance of retaining walls is provided in paragraphs 2.6.7 and 2.6.8.
- 2.6.3 Useful guidance and interpretation of highway law can be found in either *An Introduction to Highway Law* [12] or in *The Highways Act 1980 with annotations by Charles Cross and Stephen Sauvain* [13]. Both publications include a number of examples of case law to demonstrate the duties and powers of a highway authority. Another useful reference document is *The Encyclopaedia of Highway Law* [14]. This and other legal reference documents can be accessed via subscription on the internet. In addition to the guidance and interpretation provided in these documents, it is important to consider each structure based on the particular circumstances that apply before coming to a decision regarding ownership and maintenance responsibility.

Bridges

- 2.6.4 The majority of bridges are maintainable at public expense unless they were built under an Act of Parliament for the construction of the canal and railway networks or built by private owners under the authority of a Royal Charter or an Act of Parliament in consideration for being allowed to charge tolls. Where a bridge carries a road, but is not maintainable by the highway authority, it is important for the highway authority to have an agreement with the owner of the bridge to clarify the demarcation of maintenance responsibilities.
- 2.6.5 Other possible exceptions are bridges built by private land owners as a means of access over or under the highway. These are often covered by agreements with the highway authority. Section 176 of the Highways Act [11] covers licences for bridges over the highway, whilst bridges under the highway are generally covered by agreements under the general provisions of the Highways Act and Section 111 of the Local Government Act 1972 [15].
- 2.6.6 An exception to the guidance given in paragraphs 2.6.4 and 2.6.5 occurs where a bridge is associated with a road which is a trunk road or was formerly a trunk road. Section 7 of the Trunk Roads Act 1946 [16] and later Section 55 of the Highways Act 1980 [11] led to the adoption by the strategic highway authority of all private bridges when a road was trunked. These bridges have generally

been passed to the local highway authority if the road was subsequently de-trunked in accordance with Section 2 of the Highways Act 1980.

Retaining Walls

- 2.6.7 Most retaining walls, which directly support the highway or support land carrying the highway (“highway retaining walls”) and are within the highway boundary, are maintainable at public expense. Occasionally such retaining walls have been built by adjoining landowners to create a more level site and so afford more useable space, e.g. for a mill, these are generally owned by, and should be maintained by, the landowner. Whilst this cannot be insisted upon by the highway authority unless covered by an agreement, the highway does have a right of support under Common Law and this can be used if the wall starts to collapse.
- 2.6.8 The responsibility for the maintenance of retaining walls which support property adjacent to the highway (“property retaining walls”) is more difficult to determine. These walls may have been built as part of the highway and as such are maintainable at public expense unless built as accommodation works for the adjoining landowner with an agreement that the landowner would maintain them in the future. Some retaining walls may have been built by the adjoining landowner to create a more useable area and as such are maintainable by the landowner. In this case, if an existing wall is liable to endanger highway users, the highway authority can serve notice, under Section 167 of the Highways Act [11], on the owner or occupier requiring them to carry out repair work to remove the danger. This can be a protracted process and the highway authority needs to consider their general duty of care to the public. Serving of such a notice imposes a duty on the highway authority to act in default of action by the owner. Section 167 also states that no new retaining wall shall be built of height greater than 4 feet 6 inches (approximately 1.37m) within 4 yards (approximately 3.66m) of a street unless it is approved by the local council following consultation with the highway authority.
- 2.6.9 The ownership and maintenance of retaining walls can be a complex issue and it is suggested that a highway authority produce and maintain a guidance note, such as that used by Lancashire County Council (see Appendix C), to clarify retaining wall responsibilities.

Railway and Canal Bridges

- 2.6.10 The Transport Act 1968 (Part VIII Bridges and level Crossings etc) [17] sought to clarify responsibilities for maintaining the structures that carry highways over the railways of the British Railways Board or the London Board, and over waterways of the British Waterways Board.
- 2.6.11 Part VIII of that Act states that where, at that time, any of the above Boards were responsible for maintaining the highway on the bridge or giving access to the bridge, they remain responsible for all but the surfacing of the highway which from that time becomes the responsibility of the highway authority as highway maintainable at the public expense. The Act provides that the highway authority is not responsible for any defect in the surface that is attributable to the failure of the Boards to discharge their responsibility. There are similar obligations on the highway authority to afford access to the Boards to carry out their maintenance work and to seek the consent of the Boards to works which might affect the loading and/or parapet height on the bridge.

- 2.6.12 The Transport Act 1968 [17] imposed upon the Boards the need to provide bridges with the required load-bearing capacity and to maintain or improve their bridges as appropriate. Except for special cases where standards are specified by a Minister, the capacity was defined as the weight of traffic which ordinarily uses or may be reasonably expected to use the highway carried by the bridge on or about the day on which the section of the Act came into force for existing bridges or, if the bridge is constructed subsequently, when it is opened to traffic. In the case of railway bridges this was further defined by The Railway Bridges (Load Bearing Standards) (England and Wales) Order 1972 (SI 1072 No. 1705) [18] where five standards of loading are applied depending on the age of the bridge or when it was reconstructed (special provision is made for specific bridges listed in Schedules 2 and 3 to this order). The five standards of loading are:
1. *Technical Memorandum (Bridges) No. BE4 The Assessment of Highway Bridges for Construction and Use Vehicles* [19].
 2. Type HA (equivalent lane loading) standard.
 3. HA and 37.5 units of HB (abnormal loading).
 4. HA and 45 units of HB.
 5. For bridges that were or were about to be weight restricted, the load bearing obligation was limited to the weight restriction.
- 2.6.13 Between 1989 and 1999 as the result of a European Directive, highway authorities were charged by Central Government with assessing the strength of bridges carrying the adopted road network and, where appropriate, with strengthening to ensure adequacy for the introduction of the 40 tonne European Standard to roads in the UK on 1 January 1999. In the case of bridges owned by the Boards and their successors, an initial assessment was required to the new code *BD21 The Assessment of Highway Bridges and Structures* [20] and its successive developments and, in the event of the assessment indicating inadequate strength, a further assessment generally to BE4 [19], to determine whether or not the owner's load bearing obligation for the structure was met. A programme of strengthening was implemented to deal with any shortfalls of strength with cost sharing determined on the degree of shortfall, the form of strengthening and the desired loading requirements for the route. Schemes are progressed under national templates for works agreements prepared by the Boards and CSS Bridges Group. Further details are provided in *Strengthening of Railtrack owned highway bridges* [21], published jointly by CSS and Railtrack, March 1999.
- 2.6.14 Bridges carrying railways or waterways over highways are usually owned by the respective Boards or their successors. Adequate consultation and liaison should take place before either the other owner or the highway authority does any work that could impact upon the interests of the other. A protocol for highway managers when working in the vicinity of railway overbridges was being prepared by CSS and Network Rail at the time of publication of this Code. Section 2.13 provides further guidance on interaction with other owners.
- 2.6.15 References to the London Board are to be construed as reference to Transport for London. See also the Channel Tunnel Act 1987 [22], s6(3), Sch.2, Pt III, para 21(4) for the application of this section to the concessionaires as defined by that Act. Other enabling legislation has been introduced to empower replacement organisations, such as London Underground Limited, to retain similar powers.

Privately maintainable bridges

- 2.6.16 There are provisions in Sections 93 to 95 of the Highways Act 1980 [11] for the highway authority to enter into agreements with the owners of private bridges for the transfer of ownership of the structure and responsibility for its improvement and maintenance. These agreements normally contain financial provisions or commuted sums to cover any outstanding liabilities. Equally Section 271 of the Act provides for agreement of transfer of tolls and subsequent compensation if necessary.
- 2.6.17 In the event of failure to agree future responsibilities either party can apply to the Secretary of State for an order under Section 93 of the Act. Such an order can require the owner or highway authority to reconstruct or improve the bridge, can determine who should maintain/operate the bridge in the future and can require the transfer of ownership.

Low or Weak Bridges

- 2.6.18 The *Traffic Signs Manual Chapter 4* [23] requires all bridges with headroom of less than 16 feet 6 inches (approximately 5.03m) to have clearly visible warning signs showing the restricted headroom. The figure shown on the signs to indicate the available headroom should be at least 3 inches less than the measured minimum clearance anywhere over the carriageway to allow a safety margin, and should be expressed to the nearest multiple of 3 inches. An allowance should also be made for any dip in the road under the bridge so that vehicles of the maximum length permitted under *The Road Vehicles (Construction and Use) Regulations 1986* [24] can safely pass under the bridge at the signed height, see *TD27 Cross-Sections and Headrooms* [25]. The maximum figure which would normally appear on a sign is 16 feet. Metric heights may be shown as well as imperial heights (it is not acceptable to simply convert the imperial measurement to its metric equivalent, the rules given in the *Traffic Signs Manual Chapter 4* [23] should be followed). Metric and imperial heights should be shown for all low bridges on main routes and on any roads used regularly by foreign drivers. These signs do not require a Traffic Regulation Order (TRO) even if a mandatory sign is used. It is recommended that mandatory signs are used at all flat deck bridges and that highway authorities put in place a programme of change if this is not the case. However, mandatory signs are not used at arch bridges unless covered by a specific TRO.



Surrey CC

- 2.6.19 Despite the signing of low bridges, virtually all of which are under railways, and the introduction of other legislation to avoid bridge strikes, the frequency of vehicles impacting on these bridge decks has almost doubled over the last decade to exceed 2,000 per year. Fatalities have occurred and the disruption and delays to the railway industry and road users arising from even the slightest impact, the effect of which always needs to be checked before trains can be cleared to use the bridge again, are very substantial. However, the issue of striking bridges over roads is not just related to low railway bridges. Most bridges are struck from time to time, the effect varying from simple scrapes to complete demolition, including those over the 16'6" minimum headroom threshold. To seek to combat the problem the DfT has set up a group, the Bridge Strike Prevention Group (BSPG), to raise awareness of the issues and identify and action initiatives to reduce the incidences of bridge strikes. The Group includes representatives of DfT, CSS, Network Rail, TfL, LoBEG, Railways Inspectorate/HSE, Freight Transport Association, Road Haulage Association, Association of Chief Police Officers, LUL, Highways Agency and others. As part of the BSPG activities, CSS in collaboration with Network Rail are developing a protocol for highway managers and bridge owners to minimise the risk of bridge strikes. This is scheduled for publication in 2005/06. The working title for the document is *Prevention of Strikes on Bridges over Highways: A Protocol for Highway Managers and Bridge Owners* and it is one of several documents produced recently to raise the awareness of the risk of bridge strikes, and give guidance on their prevention.
- 2.6.20 Sections 1 and 2 of the Road Traffic Regulation Act 1984, as amended [26], are used by a highway authority to make a TRO (called a "Weight Restriction Order" although actually a TRO) prohibiting certain vehicles from using a bridge which has a load bearing capacity less than that required to safely carry all vehicles permitted under *The Road Vehicles (Construction and Use) Regulations 1986* [24] or *The Road Vehicles (Authorised Weight) Regulations 1998* [27]. "Weak Bridge" warning signs should be erected in accordance with *Traffic Signs Manual Chapter 4* [23] using guidance in *BD21* [20] and *BA16* [28] to determine the appropriate weight restriction with appropriate advance signing. Section 7.7 of this Code gives guidance on when a TRO is considered appropriate.

Culverts

- 2.6.21 Culverts, if constructed as part of a highway scheme, are maintainable by the highway authority. In doing this the authority may have interfered with the natural capacity of the watercourse upstream, and might as a result have some responsibility if flooding occurs because the culvert is not large enough to take all the flow. Depending upon the size of storm causing the flooding, this may be an actionable nuisance, as in the case of *Bybrook Barn Centre v Kent CC* [29], and should be duly considered, where relevant. This is also relevant to bridges over watercourses. As this is a complex issue, it is suggested that a highway authority produce and maintain a guidance note, such as that used by Kent County Council (see Appendix D), to clarify how the matter of flooding should be considered. The Environment Agency and, if appropriate, District Council should be consulted when producing the guidance note and when undertaking work on culverts/bridges that may interfere with the natural capacity of a watercourse.

Other highway structures

- 2.6.22 Other structures, such as gantries and cantilever traffic signs, constructed as part of a highway, are also maintainable at public expense and are usually managed by the bridge manager of the highway authority.
- 2.6.23 If a highway runs along the seashore then an embankment, seawall and/or groynes may be necessary for protection. They will therefore need to be maintained by the highway authority as part of their duties to maintain under the Highways Act 1980 [11], (see the case of *Sandgate UDC v Kent County Council 1898* [30]). However, each case should be considered on its merits depending on the particular circumstances, as maintenance could be the responsibility of or shared with the District Council or Unitary Authority as Coast Protection Authority.

Cellars and vaults

- 2.6.24 The majority of cellars and vaults associated with the highway are privately owned and their maintenance and management is largely outside the remit of the authority. Nevertheless, when a private cellar or vault collapses it is frequently the responsibility of the authority's bridge manager to oversee initial investigation and subsequent repairs. In order to minimise the risk to the public and the length of time taken to return the highway to public use, the bridge manager may wish to implement procedures or protocols to mitigate the risk of collapse and deal with subsequent investigation and repair. Guidance is provided in the following paragraphs on developing such a protocol.
- 2.6.25 Sections 179 and 180 of the Highways Act 1980 [11] give procedures for the control of the construction of cellars and vaults under the street, of the provision of openings under the street, and of pavement lights and ventilators. The duty to maintain and repair a cellar or vault is on the owner or occupier, whereas the highway authority has a right of support of the highway and has powers to enter and maintain existing structures if the owner or occupier fails to act. The Act does not necessarily impose an obligation on the owner or occupier to carry out works that enhance or improve, e.g. strengthening to carry current accidental wheel loads or vehicle loading, if the carriageway needs to be extended over the cellar or vault.
- 2.6.26 Authorities should implement a procedure for dealing with cellars and vaults that reflects the nature and number of cellars and vaults associated with their highway. The procedure should take into account current data and knowledge (e.g. number of recent failures), the resources needed to collect further data (e.g. a survey to identify all cellars and vaults) and the benefits provided by this data. The following approaches should be considered:
1. *Ad hoc approach* – after a collapse the authority liaises with the owner/occupier regarding the repair. There is no set protocol for dealing with collapse/repair but the Emergency Preparedness procedure described in Section 5 (*Maintenance Planning and Management*) should be followed after a collapse. This approach may be suitable for authorities that have a small number of cellars and vaults associated with their highway and have had few collapses in the past and the risk of collapses in the future is judged to be small.

2. *Re-active protocol* – after a collapse the authority follows a set protocol. The protocol may include:
 - a. Secure the site, e.g. site safety, traffic management, initial inspection and structural analysis.
 - b. Identification of relevant parties, e.g. owner, occupier, highway and other authorities.
 - c. Investigation, e.g. nature of the cellar/vault, extent and cause of damage, scope and cost of works required and constraints.
 - d. Repairs, e.g. establish who will carry out the repairs, identify work required to meet current standards and agree how costs will be shared between the parties.

This approach may be suitable for authorities that have a large number of cellars and vaults associated with their highway, but have had few collapses in the past and the risk of collapses in the future is judged to be small.

3. *Pro-active protocol* – based on the re-active protocol but add to this a pro-active approach to collapse mitigation using risk assessment. The authority, in agreement with cellar/vault owners, develops a risk assessment procedure that identifies those cellars and vaults most at risk. These structures should be inspected/assessed by the authority or the owner's engineering representative (as agreed) and the need for repairs and strengthening identified. Identification, inspection and assessment of all cellars and vaults are likely to be difficult and expensive tasks. This approach should be justified on the basis of minimum whole life costs (to the owner and authority) and may be suitable for authorities that have a large number of cellars and vaults associated with their highway and have had a significant number of collapses in the past.

2.6.27 Sections 3 to 11 of the Code do not provide specific guidance for cellars and vaults but should be considered where they would result in more effective and efficient management.

Improvements and reconstruction

2.6.28 Sections 62 to 105 of the Highways Act 1980 [11] give general powers to the highway authority to improve the highway be it widening, junction improvements or safety aspects. Improvements can include highway structures. Section 75(2) requires consent of the railway, canal, inland navigation, dock or harbour undertakers concerned, if affected.

2.6.29 Sections 91 and 92 of the 1980 Act respectively state that a highway authority can construct a bridge to carry the highway and that a bridge can be reconstructed either at the site or within 200 yards (approximately 183m) of the existing one. Section 93 of the Act permits the highway authority to apply to the Minister of State for an order to provide for reconstruction, improvement or maintenance of privately maintained bridges if they are considered dangerous or unsuitable for the requirements of road traffic.

- 2.6.30 The highway authority has the power under the 1980 Act, Section 110 to divert non-navigable watercourses if necessary or desirable as part of improvement or alterations.
- 2.6.31 Construction of bridges over, and of tunnels under, navigable waterways, requires an order from the Minister under Section 106 of the Highways Act 1980 [11]. If the waterway is also tidal, consent is required under the Coast Protection Act 1949 [31] as amended by Section 36 of the Merchant Shipping Act 1988 [32]. If material is to be deposited in the tidal waterway, consent is also required in accordance with the Food and Environmental Protection Act 1985 Part II [33]. Each of these processes involves a statutory consultation process which includes the Environment Agency, navigation authorities, Trinity House, etc as necessary.

Party Wall Act

- 2.6.32 The Party Wall Act 1996 [34] requires the issue of statutory notices when work affects adjacent properties within 3 metres of any construction works or within 6 metres if affecting foundation support. The Act is only considered applicable if the highway land is owned by the highway authority. However the authority still has a duty to maintain support of the highway under Common Law. Condition surveys should be undertaken prior to any major works and in some instances the processes prescribed within the Party Wall Act may prove beneficial. The process may lead to an affected party appointing an Independent Party Wall Surveyor to act on their behalf and thus later disputes may be avoided. Further information may be obtained from the website of the Pyramus and Thisbe Club (www.partywalls.org.uk), which is the organisation for professionals specialising in party wall matters.

New Roads and Street Works Act

- 2.6.33 The New Roads and Street Works Act 1991 [35] has considerable effect on maintenance work and is dealt with in detail in paragraphs 2.13.27 to 2.13.41.

National Variations

- 2.6.34 The Roads (Scotland) Act 1984 [36], similarly sets out the main duties for roads authorities in Scotland. Sections 1 to 4 set out the general powers and duties and state that a local roads authority shall manage and maintain all such roads entered on the list of public roads. Sections 75 to 82 deals with bridges, tunnels and diversion of watercourses in a similar manner to Sections 106 to 111 in the Highways Act 1980 [11] for bridges in England and Wales. Part V covers roads and building control, in particular Section 66 covers maintenance of vaults and cellars and requires owners to maintain and repair such structures, and gives the Roads Authority powers to serve notice on the owner to undertake repairs.
- 2.6.35 Section 90 of the Roads (Scotland) Act 1984 [36] gives powers to the roads authority to consent to structures or apparatus constructed over the road. This is similar to Section 176 of the Highways Act 1980.
- 2.6.36 The equivalent legislation in Northern Ireland is The Roads (Northern Ireland) Order 1993 [37] where the duty to maintain is contained in Article 8.

2.7 HEALTH AND SAFETY REQUIREMENTS

- 2.7.1 Highway structure maintenance, including inspections, testing and monitoring, must be managed to comply with the requirements of the Health and Safety at Work Act 1974 [38]. The Act has spawned a number of Regulations amplifying its requirements and many corresponding Approved Codes of Practice and guidance documents. A list of the current Regulations and guidance documents that might be relevant to management, maintenance and construction work on structures is provided in Appendix E. The list provided in Appendix E was relevant at the time of publication of this Code (September 2005). The list may not be comprehensive and should therefore be reviewed to identify other Health and Safety legislation relevant to the management of highway structures. The list should be updated as legislation is amended, added and removed.
- 2.7.2 The general purpose of the Act [38] is 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 bridge manager would be defined as an employer, under the Act, 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 the health and safety systems of the employed organisations in order to protect the *employer's* interests under the Act as well as satisfying themselves initially of the competence of the organisation before employing them.
- 2.7.3 Health and safety issues requiring attention during normal maintenance work include:
1. Working on construction sites.
 2. Parking vehicles and moving on foot alongside live carriageways.
 3. Traffic management to allow access.
 4. Working at height to access elements of structures to be inspected, maintained or painted, using scaffold, mobile elevating work platforms, etc.
 5. Working in, on or adjacent to water, railways, etc.
 6. Toxic substances – lead in paint, solvents, resins, cement, etc and asbestos (see paragraph 2.7.8).
 7. Lone working, e.g. by bridge inspectors.
 8. Night work.
 9. Working in confined spaces.
- 2.7.4 Organisations undertaking maintenance operations should have standard procedures for dealing with typical situations. It is important that personnel are properly trained to recognise unusual situations and to carry out risk assessments for themselves when necessary.

- 2.7.5 The specific regulations that have a considerable impact on managing highway structures change over time. At the time of publication of this Code (September 2005) regulations that had a considerable impact on the management of highway structures included:
1. *The Construction (Design and Management) Regulations 1994 (CDM)* [39].
 2. *The Control of Asbestos at Work Regulations 2002 (CAWR)* [40].
- 2.7.6 The CDM Regulations lay down specific duties for the *Client* of a construction project. The duties are to:
1. Assess, before appointments are made, the Health and Safety (H&S) competence of the other duty holders under the Regulations – planning supervisor, designers, principal contractor.
 2. Provide all available H&S information on an existing structure or site to the other duty holders.
 3. Allow sufficient time for both design and construction to be carried out with due attention to H&S.
 4. Ensure the Principal Contractor has a suitable H&S plan in place before construction works start.
 5. Retain the H&S File for the project for future reference.
- 2.7.7 The bridge manager has additional duties if he acts as designer and/or planning supervisor. In order to understand the duties of all parties under the *CDM Regulations 1994* [39] fully, it is useful to refer to a copy of *Managing Health and Safety in Construction* [41], the Approved Code of Practice for the CDM Regulations. In addition the CITB publication *CDM Regulations: Practical Guidance for Clients and Clients' Agents* [42] and the appropriate references provided in Appendix E should be considered.
- 2.7.8 *The Control of Asbestos at Work Regulations 2002 (CAWR)* [40] contain a requirement that one should assume that asbestos is present unless it can be shown that there is none. From May 2004 the CAWR [40] require the organisation or person controlling premises to have an Asbestos Management Plan for the premises. The Plan is to be made available 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. Thus the bridge manager has a duty to have in place a plan for managing asbestos in each structure, unless it has been shown that there is none, and for controlling access to the structure. 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. There must also be a named "Dutyholder" who is responsible for operation of the Asbestos Management Plan and revising it as necessary.
- 2.7.9 The Highways Agency and the Scottish Executive were preparing Interim Advice Notes on the application of the CAWR [40] to highway infrastructure at the time of publication of this Code. Although the Advice Notes are developed for trunk road assets, they provide valuable practical guidance for those managing similar assets. Good practice would indicate that an intrusive

investigation (Type 3 asbestos survey) would be carried out on any structure where records showed that there could be a reasonable risk of the presence of asbestos before designing repair, demolition or modification work.

2.8 STANDARDS FOR MAINTENANCE

- 2.8.1 All maintenance work should preferably be designed to current standards, although there may be situations where lesser standards are acceptable, e.g. repair of part of an element, repair of accident damage. Each case should be considered on its merits. Where lesser standards are accepted, the designer should check that the load carrying capacity of the structure at both serviceability and ultimate limit states and the durability of the repaired area are not less than that of the rest of the structure. Lesser standards may be unavoidable, e.g. maintenance of a listed bridge or scheduled monument. In this situation it is recommended that a safety audit or risk assessment is carried out. This documentation should be kept with the structure file for the structure in question. Where unacceptable risks or hazards are identified, the bridge manager should look for alternative mitigation measures. It is important that the implications for future maintenance are a prime consideration in the design and implementation of all maintenance schemes.
- 2.8.2 All structural design and assessment should be subject to a formal Technical Approval procedure such as those used by the Highways Agency [*BD 2; Technical Approval of Highway Structures*, 43] or Network Rail [*GC/RT5101 Technical Approval Requirements for Changes to the Infrastructure*, 44]. Authorities should have such a procedure in place and have formally appointed an organisation or individual to act as Technical Approval Authority (TAA) on their behalf.
- 2.8.3 Technical Approval is a formal arrangement by which the TAA agrees the basis on which structural design or assessment is to be carried out. It confirms the scope of the structural design or assessment together with the standards to be used and the form of analysis. It also considers whether the main components of the proposed work are satisfactory in relation to future maintenance. It includes a formal certification process at the end of design or assessment and completion of construction.
- 2.8.4 Both the Highways Agency and Network Rail have a range of documents applicable to maintenance and that refer to the relevant British Standards and Eurocodes. Appendix B gives details of these documents and how they may be accessed. The documents are specifically written for use with trunk road and railway structures but are generally applicable to all highway structures and should be used where appropriate. In certain circumstances the requirements of the documents may need to be modified to suit local roads. Departures from these standards should be carefully recorded to enable an audit trail for certification.
- 2.8.5 Currently a development programme for the introduction of Eurocodes to replace the British Standards for the design of highway structures is in progress. There will be a phased introduction of the Eurocodes but they should be available for use by 2007, with planned withdrawal of the relevant British Standards by 2010. There will be National Annexes to each code. The Design Manual for Roads and Bridges (DMRB) is likely to remain, albeit considerably amended, to assist implementation of the Eurocodes and to give guidance on those matters not covered by the Eurocodes.

National Variations

- 2.8.6 The DMRB is used by Roads Authorities in Scotland with some specific variations appropriate for use in Scotland. The Scottish Executive issues interim amendments as necessary. Similarly, the DMRB is implemented by the National Assembly of Wales.
- 2.8.7 The DMRB is used in Northern Ireland by Roads Service, an Executive Agency within the Department of Regional Development (DRD), with some specific variations appropriate for use in Northern Ireland. Roads Service issues interim amendments as DEMs (Director of Engineering Memoranda) as necessary and Northern Ireland specific policy as RSPPGs (Roads Service Policy & Procedure Guide).

2.9 ENVIRONMENTAL REQUIREMENTS

- 2.9.1 Maintenance work on highway structures, including inspection, should be undertaken giving due consideration to the environment. There are significant areas of legislation that must be complied with. Brief details of the requirements are given below together with guidance on when they may apply.
- 2.9.2 The EC directive 85/337/EEC “The assessment of the effects of certain public and private projects on the environment” [45] came into effect in July 1988 and initiated a formal approach to environmental assessment. The directive required an environmental assessment to be carried out prior to development consent being granted for certain types of major projects. The directive was subsequently amended by Directive 97/11/EC [46] to extend the list of projects. Annexes to these directives determine whether the assessment is mandatory (Annex I) or discretionary (Annex II). Section 105A of the Highways Act 1980 [11] was amended in 1988 to include these requirements for highway schemes. Section 20A and 20B of the Roads (Scotland) Act 1984 [36] was similarly amended in 1999.
- 2.9.3 With the exception of large bridge replacement schemes, most maintenance for highway structures is likely to be too small to fall within the Annex I criteria. However, the Directive applies to all work that encroaches within 100m of an environmentally sensitive site as defined in the directives.
- 2.9.4 An environmental scoping report may not be necessary for minor maintenance schemes and inspections, but it should be prepared in all other maintenance schemes and inspections. The report should be submitted to the planning department of the local authority for a screening opinion on any further action needed. A protocol should be developed jointly with the local planning team to determine levels of intervention and content of these scoping reports for different types and scale of projects.
- 2.9.5 Even in the event that a formal environmental statement is not required, it is good practice to prepare an Environmental Management Plan for each scheme and inspection which significantly affects the area round the structure. The Plan should identify the likely environmental impacts. Work specifications should be developed to address these issues and minimise the impacts.
- 2.9.6 Particular consideration needs to be given to protected species of flora and fauna, bats, otters, wolverines, great crested newts, etc. The bridge manager may be familiar with these species but expert advice is required to identify particular environmental issues at a particular site. Licences are required to be

issued by DEFRA in England under the *Conservation (Natural Habitats, &c) Regulations 1994* [47] for work affecting protected species. The appropriate nature conservation body has to be consulted prior to the issue of licences. Early consultation on method of working is therefore essential.

- 2.9.7 Appendix A gives details of suitable sources of environmental guidance.
- 2.9.8 Scottish Natural Heritage and Scottish Environment Protection Agency are the statutory bodies in Scotland that have responsibility for the environment.
- 2.9.9 The Environment and Heritage Service, an Agency within the Department of the Environment (DOE), is the statutory body in Northern Ireland responsible for the environment (www.ehsni.gov.uk).

2.10 SUSTAINABILITY REQUIREMENTS

- 2.10.1 The UK Government, like others in the international community, has recognised the need for sustainable development. At the time of publication of this Code, the UK Government was committed to achieving the targets agreed at the world summit on sustainable development held in Johannesburg in 2002.
- 2.10.2 A widely-used international definition of sustainable development is **“development which meets the needs of the present without compromising the ability of future generations to meet their own needs”**.
- 2.10.3 The Department of Trade and Industry (DTI) has published a *Sustainable Construction Brief* [48], based on the above definition, that suggests key themes:
 - 1. Design for minimum waste.
 - 2. Lean construction (to minimise waste).
 - 3. Minimise energy in construction and use.
 - 4. Do not pollute.
 - 5. Preserve and enhance biodiversity.
 - 6. Conserve water resources.
 - 7. Respect people and local environment.
 - 8. Set targets (i.e. monitor and report, in order to benchmark performance).
- 2.10.4 Each sector amongst the suppliers of construction material has published a strategy for their areas of development. The Institution of Civil Engineers is leading the sustainability agenda in the general civil engineering sector. The DTI web site (www.dti.gov.uk) provides a number of links to other sites that are useful references for sustainability.
- 2.10.5 Strategy and guidance for sustainable development are rapidly evolving and will have an impact on the bridge manager. The UK Government, Scottish Executive, Welsh Assembly and Northern Ireland Administration are jointly developing a strategic framework for sustainable development for implementation (further details can be found at [66](http://www.sustainable-</div><div data-bbox=)

development.gov.uk). Local authorities have been invited to participate in the development and to amplify some of the relevant issues. It is likely to be a number of years before the detailed guidance required for highway structure sustainable development come out of the framework. In the interim, it is recommended that the key items listed in paragraph 2.10.3 be considered as a minimum for highway structures maintenance schemes.

- 2.10.6 Research work carried out by BRE is investigating the potential for an environmental sustainability assessment tool that informs highway structures management decisions. This research has been supported by Surrey County Council. Use of such a tool appears to be one way forward in achieving a more sustainable management process. Papers such as *Highway bridges and environment – sustainable perspectives* [49] and *Environmental impact of brick arch bridge management* [50], which are summarised in *Environmental Sustainability in Bridge Management* [51], provide an outline of this research and some tentative conclusions. The initial research indicates that from a sustainability perspective it may be better to maintain, refurbish or strengthen a structure rather than demolish it and rebuild. The initial research also indicates that the environmental burden of traffic disruption and vehicle diversions can make a significant contribution to the overall environmental impact of bridge maintenance and as such should be minimised. Further research is required before a practical tool is available.

2.11 CONSERVATION REQUIREMENTS

- 2.11.1 The Planning (Listed Building and Conservation Areas) Act 1990 [52] requires each local authority to compile a list of buildings of special interest, either historic or architectural. Listed building consent is required to demolish such a structure, or to alter or extend it in a manner affecting its architectural or historic interest. The Act also provides for the protection of conservation areas that have special historical interest. The status can influence the processes required for structure maintenance in such an area.
- 2.11.2 There are different grades of listing, depending on the historical or architectural importance of the structure, ranging from Grade 2 through Grade 2* to Grade 1, with a further level of Scheduled Ancient Monument, which is covered by The Ancient Monuments and Archaeological Areas Act 1979 [53]. Secretary of State (Department of Culture, Media and Sport) approval of proposals for work on a Scheduled Ancient Monument is required before any works are carried out, except emergency works. The Ancient Monuments (Class Consents) Order 1994 [54] gives consent in Class 5 for works which are urgently necessary in the interests of safety or health, provided that the works are limited to the minimum measures immediately necessary and notice in writing justifying in detail the need for the works is given to the Secretary of State as soon as reasonably practical. This would allow the replacement of the odd damaged stone or realignment of a displaced parapet, but not repair of more extensive damage. The Secretary of State relies heavily on the advice of English Heritage and any proposals for work on such structures should involve early consultation with the local representative of English Heritage. Proposals for works on structures recorded at the lower (listed) levels are usually approved by the planning department of the local authority. However, if the work will require complete or partial demolition, or if the work will alter or extend a Grade 1 or 2* structure in any manner which would change its character as a building of special architectural or historical interest, the planning department of the local authority has to consult the Office of the Deputy Prime Minister who will be advised by English Heritage.

- 2.11.3 There are currently 25 World Heritage sites within the UK designated by UNESCO (United Nations Educational, Scientific and Cultural Organization). The website address is whc.unesco.org. Although these sites have no greater legislative protection, local planning authorities are encouraged to have management plans in place. Planning applications for works in these areas are likely to require greater consultation and thus lengthier programmes should be accommodated. Details of these sites are provided on the English Heritage website (www.english-heritage.org.uk).
- 2.11.4 As the requirements for the conservation of historic structures are specified in a number of disparate documents and there was a need to bring them together in a bridge-orientated publication, the Highways Agency sponsored the publication of *Conservation of Bridges* [55] and issued *BD89 The Conservation of Highway Structures* [56]. Both these publications should be consulted before work is proposed on historic structures. The website www.maintainourheritage.co.uk, although primarily for historic buildings, has information on various aspects of maintaining these structures.

National Variations

- 2.11.5 In Scotland, Historic Scotland (www.historic-scotland.gov.uk) has been set up by the Scottish Executive to undertake a similar role to that of English Heritage for ancient monuments. The same legislation is applicable for ancient monuments, except for listed buildings. They are covered by Planning (listed buildings and conservation areas) (Scotland) Act 1997 [57].
- 2.11.6 Cadw, created in 1984, is the historic environment agency within the Welsh Assembly Government and deals with the preservation of ancient monuments in Wales (www.cadw.wales.gov.uk).
- 2.11.7 The Environment and Heritage Service, an Agency within the Department of the Environment (DOE), is the statutory body in Northern Ireland responsible for the conservation of the natural and built environment (www.ehsni.gov.uk).

2.12 STAKEHOLDER CONSULTATION AND INVOLVEMENT

- 2.12.1 The success of any maintenance scheme for highway structures is highly dependent on the interaction with all affected parties or stakeholders. Overlooking a single party can seriously jeopardise the successful outcome of a scheme. Early consultation is vital and regular interaction during a project and feedback on completion is also necessary to maintain the commitment of all stakeholders.
- 2.12.2 The initial phase of a maintenance scheme should involve an information gathering exercise to identify all affected parties. Highway authorities often have a standard list of consultees. Such lists require careful consideration to identify any site specific stakeholders who may not be on the list, for example, the owner of the local shop or the daughter of the housebound pensioner that lives just beyond the bridge and needs to visit them twice a day. Temporary road closures can have a significant impact on this type of stakeholder. Fundamental to asset management and the Best Value ethos is stakeholder consultation, and rightly so since the highway and bridge are there to serve the stakeholder.
- 2.12.3 As stated in Section 2.6 (*Legal and Procedural Requirements*), there are a number of parties that should be consulted depending on the individual

circumstances. A short list of consultees is attached as Appendix F. The list is not exhaustive but gives an indication of those to be contacted during the consultation process.

- 2.12.4 Effective communication and consultation, internally between departments and area offices and externally with adjacent highway authorities, are fundamental to demonstrate efficiencies, time and cost savings and essential to avoid embarrassing clashes of requirements for road space.

2.13 INTERACTION WITH OTHER OWNERS AND THIRD PARTIES

- 2.13.1 The bridge manager must be prepared to work with other owners and third parties in order to maintain the safe operation of the public highway and to carry out maintenance work.

Traffic Managers

- 2.13.2 In accordance with the Traffic Management Act 2004 (TMA) [58], each local highway authority in England and Wales has a duty to manage its road network in a manner that secures expeditious movement of traffic, maximises capacity and minimises disruption. In doing so an authority should take due account of the movement of traffic on the networks of other authorities. Each authority is required to appoint a Traffic Manager to manage the network. It is important that the bridge manager liaises with traffic managers of all affected authorities as early as possible in order to coordinate activities with any other ongoing or planned works. The TMA also introduces changes to NRSWA [35] (also see paragraph 2.13.27 to 2.13.41) to allow the Traffic Manager to undertake their duty. These changes include the introduction of permits, Fixed Penalty Notices and changes to the level of fines, enhanced Section 56 and Section 58, as well as requiring that all works in the highway (including highway and bridge works) are treated equally.

Access

- 2.13.3 Maintenance work, including inspections, frequently requires access onto land in other ownership, either at the structure or gaining entry to it. The highway authority or other owner does not necessarily own the land adjacent to a structure or under a bridge or have a right to access covered by a legal agreement. Records should be consulted and any landowners contacted to agree arrangements. If agreement cannot be reached it may be necessary for the highway authority to use the powers in the Highways Act 1980 [11] (Sections 289 to 292) or equivalent legislation in Scotland and Northern Ireland.
- 2.13.4 Access to the structure should be arranged so as to minimise damage to the environment. On agricultural land, for example, the timing of the inspection can be significant due to possible damage to growing crops or interference with other farming activities. There may also be a need for special precautions to avoid the spread of animal or plant diseases. Vehicles and equipment can cause rutting or ground compaction as well as direct damage to the vegetation.
- 2.13.5 Access for work on structures over or adjacent to operational rail lines and canals or navigable waterways is covered in paragraphs 2.13.13 to 2.13.17.

Border agreements

- 2.13.6 Section 3 of the Highways Act 1980 [11] states that when a bridge straddles a boundary between highway authority areas an agreement has to be entered into between the two authorities whereby one of the authorities becomes the highway authority for the whole bridge and its approaches. Normally all the structures crossing a particular boundary are considered and a fair distribution of individual structures is agreed between the authorities.
- 2.13.7 These agreements should be adequately documented and recorded to enable effective future management and adjustments that may be required to accommodate changes to local authority boundaries and any further local government reorganisation.
- 2.13.8 Maintenance on structures that straddle authority boundaries necessitates an especially high level of consultation, communication and joint planning of operations between the authorities. Work on strategic routes can also have a significant impact on the whole highway network of adjoining authorities and significant costs may result. Particular attention should be given to emergency planning for these types of structure as any major incident can have a significant effect on both authorities. Section 5 (*Maintenance Planning and Management*) provides guidance on emergency planning.

Structures owned by other bodies

- 2.13.9 Highways are frequently supported by or go under structures owned by parties other than the highway authority for that highway. Typically, local highways go under and over trunk roads, trunk motorways, live and disused railways, canals, and private accesses. The bridges may be owned by the Highways Agency, Scottish Ministers, Network Rail, London Underground Limited, BRB Residuary Ltd (formerly Rail Property Ltd), British Waterways, Environment Agency, Internal Drainage Boards, other public authorities or private owners.
- 2.13.10 A clear definition of responsibilities in respect of the structure and related elements should be prepared for all such situations. Section 2.5 (*Legal and Procedural Requirements*) provides the legislative background to these responsibilities. Responsibilities are based generally on the reasons the bridge was built and on the need to ensure the integrity of safety and protection systems.
- 2.13.11 There is also a residual responsibility on the highway authority, in respect of the public using its roads, relating to bridges owned by other bodies. The authority has a responsibility to seek to ensure that other owners are exercising adequate stewardship over their structures. The Highways Act 1980 [11] Section 56 allows proceedings for an order to enforce repair. Whilst it is reasonable to assume that major infrastructure owners such as Network Rail, the Highways Agency and British Waterways will be competent in this regard, this level of confidence cannot be taken for granted elsewhere. Advice is given in Section 6.4 (*Inspection Regime*) of this Code on appropriate levels of audit inspection which a highway authority might exercise in these situations.
- 2.13.12 Section 130 of the Highways Act 1980 [11] allows proceedings for the protection of public rights and can be used by highway authorities to enforce another owner to undertake maintenance. This was used in the particular case *Railtrack Plc v London Borough of Wandsworth EWCA* [59], where droppings from pigeons roosting in an overbridge were causing a public nuisance.

Structures over or adjacent to operational rail lines

- 2.13.13 When required to undertake inspections or maintenance work on structures over or adjacent to operational railways, the bridge manager of the highway authority is required to adhere to Network Rail, procedures for outside parties. Early notice is necessary to enable the Outside Parties Manager of Network Rail to book track possessions and attendance to facilitate safe access to undertake the work. Similar procedures are required for operational underground and metro systems. Heritage railways often follow similar systems to their previous operators.



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- 2.13.14 A process flow chart is provided in Appendix G to guide the bridge manager through the process of liaison with Network Rail for works affecting the railway which have been initiated by the highway authority. This process, which includes notification, possession booking and agreement of method statements, is shown in outline only and may vary between the regions of Network Rail, and the process may involve external contractors and consultants employed by Network Rail. London Underground Limited (LUL) and other rail operators are likely to have similar procedures. The bridge manager should liaise directly with the appropriate operator for details.
- 2.13.15 The process for joint strengthening schemes is different and is covered by the agreements referred to in paragraphs 2.6.10 to 2.6.15.

Structures over or adjacent to canals or navigable waterways

- 2.13.16 Inspections or maintenance work on structures over or adjacent to canals or navigable waterways should be carried out in such a way as to ensure the safety of waterway users and the integrity of the waterway. British Waterways or the relevant navigation authority may require the bridge manager of the highway authority to adhere to their procedures. These procedures may be covered in the agreement for the construction of the structure, but in the absence of an agreement or if the agreement is silent, highway authorities can use their powers under Sections 289 and 291 of the Highways Act 1980 [11] to gain entry with compensation being determined in accordance with Section 292. As the work being undertaken is primarily for the benefit of highway users and not canal users then Section 118 of the Transport Act 1968 [17] does not apply. Documents, such as the *British Waterways Code of Practice* [60], are not mandatory, although certain sections need to be adhered to in order to ensure the safety of canal users.

- 2.13.17 Early consultation is necessary to enable the bodies concerned to programme the work so as to minimise the effect on users of the waterway. British Waterways require all work which may cause a restriction or closure of the waterway, to be agreed before the 31st March of the current financial year for work to take place in the following financial year.

Structures over or adjacent to watercourses or flood defences

- 2.13.18 If highway structure works are required in, over, under or near a watercourse or flood defences (including sea defences), it is essential to contact the Environment Agency in England and Wales in order to obtain the necessary consents. Contact details for the Environment Agency are provided in Appendix A. Consents can take two months to obtain and should therefore be sought as early in the planning process as feasible, i.e. when sufficient details about the works can be submitted to the Environment Agency.
- 2.13.19 Consents are the means of meeting requirements that the works do not endanger life or property by increasing the risk of flooding or cause harm to the water environment. Consents are given under the Water Resources Act 1991 [61] for main rivers and under the Land Drainage Act 1991 [62] for other watercourses. In some areas there are Internal Drainage Boards who deal with these matters on behalf of the Environment Agency.
- 2.13.20 Watercourses in Scotland are the responsibility of the Scottish Environmental Protection Agency (SEPA), contact details are in Appendix A, and local authorities.
- 2.13.21 The Rivers Agency, an Executive Agency within the Department of Agriculture and Rural Development (DARD), is the statutory drainage and flood defence authority for Northern Ireland (www.riversagency.dard.gov.uk).

Developer promoted structures

- 2.13.22 All proposals for new structures within or over an existing or proposed highway or works which affect existing highway structures should be subject to a formal Technical Approval (TA) process (see paragraph 2.8.2).
- 2.13.23 Highway managers and District Planning Authorities should inform developers at the outset of development proposals that they must obtain TA for their designs and inform highway authorities of the proposals immediately they become known. This action will encourage development of the Approval in Principle (AIP) at the beginning and avoid potentially abortive work by the developer.
- 2.13.24 Structures being built as part of any development, irrespective of whether or not they will be maintainable by the highway authority, are included in the TA process if they:
1. Are adjacent to the highway and interfere with the support of the highway or access to it for inspection and maintenance.
 2. Form part of any road that is to be adopted into the highway under a Section 38 [Highways Act 1980, 11] agreement.
 3. Form part of any road that is being built under a Section 278 [Highways Act 1980, 11] agreement.

- 2.13.25 Guidance, in the form of a process, for dealing with developer promoted structures is given in Appendix H.
- 2.13.26 The Northern Ireland Roads Service has published a guidance leaflet, *Technical Approval of Highway Structures: Information for Developers and their Designers*, which is available at www.roadsni.gov.uk/Publications/specific/specific.htm.

Utility companies and NRSWA

- 2.13.27 Utility companies operate under statutory powers provided and obligations imposed by enabling legislation which is specific to each industry. They are empowered by statute to undertake street works.
- 2.13.28 The New Roads and Street Works Act 1991 (NRSWA) [35] as amended by the TMA [58] controls and co-ordinates work carried out in the street by utility companies (undertakers), also see paragraph 2.13.2. The Act also requires the highway authority to take due regard of undertaker's apparatus when planning and carrying out highway and bridge works. It is essential that, before any work in the ground occurs, all statutory undertakers are consulted regarding the presence of apparatus and appropriate notice given. Reliance should not be placed on information on a highway structures' database regarding apparatus as it could be out of date.
- 2.13.29 Detailed interpretation of and guidance on the use of the Act has been published in the DfT *New Roads and Street Works Act 1991 and Traffic Management Act 2004; Code of Practice on Co-ordination; Volume 2: Operations and Guidance; Section 5: Street Works near Highway Structures* [63].
- 2.13.30 The Highway Authorities and Utilities Committee (HAUC(UK)), a national group representing local authority associations and the National Joint Utilities Group, have produced a number of codes of practice dealing with the Act. *Measures necessary where apparatus is affected by major works (Diversionary works)* [64], sets out the procedures involved from the early stages of a highway or bridge scheme including requirements for budget estimates, to the construction stage and early payments.
- 2.13.31 Section 50 of the Act contains provisions for issuing licences for apparatus to be installed in the highway by persons other than statutory undertakers, e.g. a private sewer. Advance notice to the undertakers is required to be given by the street authority when such a licence is to be issued and details of the installation are to be recorded by the street authority.

Obligations of Undertakers

- 2.13.32 Before carrying out any work, undertakers are required to give notice to the street authority (not always the highway authority). Designated notice periods are given in the Act or associated Code of Practice. These notification periods are intended to give the street authority an opportunity to consider and comment on the implication of works proposals for the highway infrastructure.
- 2.13.33 Section 88 of the Act imposes an additional obligation on an undertaker proposing works affecting the structure of a bridge. The undertaker is required to consult the bridge authority before giving the usual notice. The undertaker is required to comply with reasonable requirements for safeguarding the structure.

- 2.13.34 Section 63 of the Act permits a street authority to designate certain streets as “streets with special engineering difficulties”. Under this section, an undertaker must submit plans and sections for approval by the authority before street works can be undertaken. This is the only time that drawing details are required. The authority has the power to require modifications if considered necessary.
- 2.13.35 Section 63 of the Act suggests that the designation of streets with special engineering difficulties may be appropriate at bridges where strength, stability, waterproofing and access for maintenance may be affected. The designation need only apply to the structure and the street directly adjacent and includes areas adjacent to retaining walls where stability may be an issue. Designating all structures under this section is recommended because it gives the greatest control over statutory undertakers working in the proximity of a highway structure, although some sub-sections of Section 88 would not apply in this case.

Obligations of the Street Authority and the Structure Owner

- 2.13.36 The street authority is required to keep a street works register under Section 53 of the Act and to include the streets with special engineering difficulties. All structures that are likely to be sensitive to undertaker’s work should be recorded in the register. The resulting register provides the bridge manager with the earliest opportunity to advise undertakers on works likely to affect highway structures.
- 2.13.37 The Act defines the requirements when undertaking major highway and bridge works. The authority is required to serve notice of the proposed works under Section 58.
- 2.13.38 Where apparatus is to be diverted for major bridge works (i.e. replacement, reconstruction or substantial alteration of a bridge), the cost of any alterations to the apparatus will be shared providing advanced notice has been served under Section 85 of the Act and the highway authority pays in advance to the undertaker 75% of the estimated charge to the highway authority. The Act and codes of practice make provision for the highway authority’s costs to be reduced to allow for betterment. Also, where the length of apparatus diverted exceeds 100 metres and that apparatus is more than 7 years old a cost adjustment should be made for financial benefit conferred on undertakers by reason of the deferment of the time for renewal of the apparatus. Guidance on the calculation of these sums is also provided in the Act. No costs of diversionary works to apparatus should be borne by the highway authority when apparatus is placed in the bridge after advance notice has been given. Advance notice may be served up to 10 years in advance of works for the replacement of a bridge and 5 years in advance for all other works. In view of the cost of diverting apparatus, it is recommended that this procedure is followed.
- 2.13.39 In all cases there is no obligation on the part of the highway authority to provide space for additional apparatus in the future. Such an approach may be prudent when reconstructing a structure or carrying out major works in order to minimise problems in the future with inappropriately placed apparatus. Any costs incurred in making provision for additional apparatus requested by undertakers may be charged to them although it is advisable not to allocate spare ducts to undertakers until they need to lay apparatus across the structure.

Regional variations

2.13.40 The NRSWA 1991 [35] provides for road works in Scotland in Sections 107-165. England and Wales are covered in the earlier sections of the Act and refer to the relevant sections of the Highways Act 1980 [11].

2.13.41 In Northern Ireland the equivalent legislation is contained in The Street Works (Northern Ireland) Order 1995 [65].

2.14 RECOMMENDATIONS

2.14.1 It is recommended that:

1. Suitably qualified and experienced personnel, including contracted staff, should be used to implement the Good Management Practice embodied in this Code. There should be a programme of training and Continuing Professional Development (CPD).
2. Up-to-date background information should be maintained on the overall management context to provide an appropriate basis for meeting the requirements and regulations for the management of highway structures. This should include Government transport policy, authority's transport policy, legal, Health and Safety, environmental, and sustainability requirements.

2.14.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Recommendation
ONE	<ul style="list-style-type: none"> • Employ suitably qualified, experienced and trained personnel (Section 2.2). • Provide a programme of CPD and training for bridge managers, engineers and other staff to enable them to understand and implement the processes necessary to provide highway structures that are safe to use, inspect and maintain (Section 2.2). • Require agents and contractors to demonstrate their personnel are adequately qualified and experienced and are provided with appropriate CPD and training (Section 2.2). • Maintain up-to-date documents on Government Transport Policy and Plans (Section 2.3) and Best Value, or equivalent, legislation (Section 2.4). • Maintain information on legal and procedural requirements (Section 2.6). • Maintain a Health & Safety policy and associated guidance notes tailored for the specific operations involved in the management of highway structures (Section 2.7). • Maintain appropriate standards for maintenance (Section 2.8). • Maintain a Technical Approval Procedure with an organisation or individual formally appointed as TAA (Section 2.8).

Milestone	Recommendation
TWO	<ul style="list-style-type: none"> • Establish a process for compiling, storing and maintaining information on the management context of highway structures. Ensure the information is readily accessible and the process has a mechanism for keeping relevant staff informed of changes, amendments, updates, etc. (Section 2.1). • Provide a programme of CPD and training for bridge managers, engineers and other staff to enable them to understand and implement the processes of Good Management Practice described in this Code (Section 2.2). • Maintain up-to-date documents on Resource Accounting and Budgeting requirements (Section 2.5). • Maintain guidance notes on the environmental (Section 2.9) and conservation (Section 2.11) requirements for management of highway structures. • Maintain procedures for stakeholder consultation and involvement (Section 2.12). • Produce and maintain guidance notes, as appropriate, for dealing with other owners and third parties, e.g. developer promoted structures and structures over/adjacent to railways or canals (Section 2.13).
THREE	<ul style="list-style-type: none"> • Continue to provide an on-going programme of CPD (Section 2.2). • Produce and maintain a guidance note on the ownership and maintenance of retaining walls and, as appropriate, a protocol for dealing with cellars and vaults and flooding at culverts (Section 2.6). • Produce and maintain a guidance note on the sustainability requirements for the management of highway structures (Section 2.10).

2.15 REFERENCES FOR SECTION 2

1. *Full Guidance on Local Transport Plans – Second edition*, Department for Transport, July 2004.
2. *Mayor’s Transport Strategy – Local Implementation Plan Guidance*, Transport for London, July 2004.
3. *Releasing resources to the front line; Independent review of public sector efficiency*, Sir Peter Gershon, July 2004, HM Treasury.
4. *Guidance on LTP annual progress reports – Fourth edition*, Department for Transport, 2004.
5. *Local Government Act 2003*, HMSO.
6. *Local Government Act 1999*, HMSO.
7. *The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002*, Statutory Instrument: 2002 No 305 Local Government, England and Wales, HMSO.
8. *Guidance Document for Performance Measurement of Highway Structures, Parts A, B and C*, www.cssnet.org, Draft Working Reports

prepared for Highways Agency and County Surveyors Society by Atkins, February 2005.

9. *Local Government in Scotland Act 2003*, HMSO.
10. *Local Government (Best Value) Act (Northern Ireland) 2002*, HMSO.
11. *Highways Act 1980*. HMSO.
12. *An introduction to Highway Law*, Michael Orlick, published by Shaw and Sons.
13. *The Highways Act 1980 with annotations by Charles Cross and Stephen Sauvain*, Sweet & Maxwell, 1981.
14. *The Encyclopaedia of Highway Law*, Sweet & Maxwell, ISBN 0421044500.
15. *Local Government Act 1972*, HMSO.
16. *Trunk Roads Act 1946*, HMSO.
17. *Transport Act 1968*, HMSO.
18. *The Railway Bridges (Load Bearing Standards) (England and Wales) Order 1972 (SI 1072 No. 1705)*, HMSO.
19. *Technical Memorandum (Bridges) No. BE4 The Assessment of Highway Bridges for Construction and Use Vehicles*, 1967 as amended up to 11th November 1970, Ministry of Transport.
20. *BD21 The Assessment of Highway Bridges and Structures*, DMRB 3.4.3, TSO.
21. *Strengthening of Railtrack owned highway bridges*, County Surveyors Society and Railtrack, March 1999.
22. *Channel Tunnel Act 1987*, HMSO.
23. *Traffic Signs Manual Chapter 4*, TSO, ISBN 0 11 552411 8.
24. *The Road Vehicles (Construction and Use) Regulations 1986*, HMSO.
25. *TD27 Cross-Sections and Headrooms*, DMRB 6.1.2, TSO.
26. *Road Traffic Regulation Act 1984, as amended*, HMSO.
27. *The Road vehicles (Authorised Weight) Regulations 1998*, HMSO.
28. *BA16 The Assessment of Highway Bridges and Structures*, DMRB 3.4.4, TSO.
29. *Bybrook Barn Centre v Kent CC 2000*, www.bailii.org.
30. *Sandgate UDC v Kent County Council 1898*.

31. *Coast Protection Act 1949 as amended by section 36 of the Merchant Shipping Act 1988*, HMSO.
32. *Merchant Shipping Act 1988*, HMSO.
33. *Food and Environmental Protection Act 1985*, HMSO.
34. *Party Wall Act 1985*, HMSO.
35. *New Roads and Street Works Act 1991*, HMSO.
36. *The Roads (Scotland) Act 1984*, HMSO.
37. *The Roads (Northern Ireland) Order 1993; SI 1993/3160 (NI 15)*, HMSO.
38. *Health and Safety at Work etc Act 1974*, HMSO.
39. *The Construction (Design and Management) Regulations 1994*, HMSO.
40. *The Control of Asbestos at Work Regulations 2002*, HMSO.
41. *Managing Health and Safety in Construction, 2001*, HSE Books.
42. *CDM Regulations: Practical Guidance for Clients and Clients' Agent*, Publication C602, Second edition, CIRIA.
43. *BD 2 Technical Approval of Highway Structures*, DMRB 1.1.1, TSO.
44. *GC/RT5101 Technical Approval Requirements for Changes to the Infrastructure*, Network Rail.
45. *The assessment of the effects of certain public and private projects on the environment*, EC directive 85/337/EEC.
46. EC directive 97/11/EC amending EC Directive 85/337/EEC on "The assessment of the effects of certain public and private projects on the environment".
47. *Conservation (Natural Habitats &c) Regulations 1994*, HMSO.
48. *Sustainable Construction Brief*, Department of Trade and Industry, www.dti.gov.uk.
49. *Highway bridges and environment – sustainable perspectives*, K Steele, G Cole, G Parke, B Clarke and J Harding, Proc. of ICE, Civil Engineering, November 2003.
50. *Environmental impact of brick arch bridge management*, K Steele, G Cole, G Parke, B Clarke and J Harding, Proc. of ICE, Structures and Buildings, August 2003.
51. *Environmental Sustainability in Bridge Management*; Kristian Steele, BRE Information Paper IP 14/04, 2004.
52. *Planning (Listed Building and Conservation Areas) Act 1990*, HMSO.

53. *The Ancient Monuments and Archaeological Areas Act 1979*, HMSO.
54. *The Ancient Monuments (Class Consents) Order 1994*, HMSO.
55. *Conservation of Bridges*, G P Tilly, Spon, 2002.
56. *BD 89 The Conservation of Highway Structures*, DMRB 3.2.4, TSO.
57. *Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997*, HMSO.
58. *Traffic Management Act 2004*, HMSO.
59. *Railtrack plc v London Borough of Wandsworth EWCA*, Civ 1236, 30 July 2001.
60. *British Waterways Code of Practice*.
61. *Water Resources Act 1991*, HMSO.
62. *Land Drainage Act 1991*. HMSO.
63. *New Roads and Street Works Act 1991 and Traffic Management Act 2004; Code of Practice on Co-ordination; Volume 2: Operations and Guidance; Section 5: Street Works near Highway Structures*, Department for Transport.
64. *Measures necessary where apparatus is affected by major works (Diversionary works)*, HAUC(UK).
65. *The Street Works (Northern Ireland) Order 1995*, HMSO.

Section 3

Asset Management Planning

This section provides an introduction to asset management and an overview of an asset management framework suitable for transport infrastructure. A long term asset management planning process for highway structures is presented, and detailed guidance is provided on how this process should be used to produce the highway structures input to an authority's Transport Asset Management Plan (TAMP). The typical contents of a TAMP are also summarised.

3.1 INTRODUCTION

3.1.1 Asset management is a modern but well developed discipline that is practiced in many countries and across a wide range of industries (including highway, railway, oil and gas, water and wastewater, aerospace and nuclear). However, it may not be a familiar subject to many bridge managers. The following provides a brief introduction to asset management.

Asset management source documents

3.1.2 The basis and principles of asset management are well documented and good sources, which give particular regard to UK transport infrastructure asset management, include:

1. *Framework for Highway Asset Management* [1]
2. *PAS 55-1: Asset Management: Specification for the optimized management of physical infrastructure assets* [2]
3. *PAS 55-2: Asset Management: Guidelines for the application of PAS 55-1* [3]
4. *International Infrastructure Management Manual, UK Edition* [4]

3.1.3 The asset management framework and planning process presented in this section align closely with the aforementioned documents, in particular the *Framework for Highway Asset Management* [1] and *PAS 55 Asset Management Guidance* [2 and 3].

Definitions of asset management

3.1.4 Recognised definitions of asset management are:

Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.

Framework for Highway Asset Management [1]

Asset management is the systematic and coordinated activities and practices through which an organisation optimally manages its assets, and their associated performance, risks and expenditures over the lifecycle for the purpose of achieving its organisational strategic plan.

PAS 55-1 – Asset Management [2]

- 3.1.5 The two definitions have the same overall meaning. The principles encompassed by these definitions are discussed in Section 3.4. However, *stakeholder* is used in this Code instead of *customer* (the term used in the first definition above), where stakeholder covers a wide range of parties with a vested interest in the management of transport assets, e.g. authority/owner, public, users, community, customers, shareholders and businesses.

Needs and drivers for asset management

- 3.1.6 Increasing pressure, including financial scrutiny, is being placed on asset managers to make the best use of available resources in delivering service requirements on an ageing infrastructure. Asset managers are required to demonstrate that planned work will deliver an authority's long term strategic goals and objectives using management processes and systems that are transparent, defensible and auditable. The development and implementation of a formalised asset management approach is needed to meet these requirements.



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- 3.1.7 The following initiatives place a requirement on authorities to develop asset management processes and systems:

1. Local Transport Plans – the *Full Guidance on Local Transport Plans: Second edition* [5] issued by the Department for Transport “strongly recommends” highway authorities to prepare Transport Asset Management Plans (TAMPs) from 2005-06.
2. Whole of Government Accounts (WGA) – a central Government initiative to produce a comprehensive set of accounts in line with the Generally Accepted Accounting Practice (GAAP) in order to bring public sector accounting in line with that of the private sector. The objectives of WGA are to promote greater accountability, transparency and improved stewardship of public finances. WGA objectives and procedures align closely with those of asset management.

3. Asset Valuation – robust asset management processes and a TAMP are required to support the asset valuation process described in the *Guidance Document for Highway Infrastructure Asset Valuation* [6].
4. The Prudential Code [7] – requires local authorities to give due consideration to option appraisal and asset management planning in order to demonstrate that their plans are affordable, prudent and sustainable.
5. Best Value Legislation [8] – asset management plays a key role in demonstrating that authorities are providing best value and supporting performance management.

Benefits of asset management

- 3.1.8 The benefits of asset management are well covered by the *Framework for Highway Asset Management* [1] and the International Infrastructure Management Manual [4]. To summarise, asset management is a stakeholder focused, systematic and holistic framework that provides a greater degree of management control and understanding. In particular, good asset management enables the consequences of underfunding to be demonstrated, thus providing justification for appropriate levels of funding.

3.2 PURPOSE

- 3.2.1 The purpose of asset management is to provide a systematic and holistic framework for the management of a group/network of assets to deliver specified, or agreed, Levels of Service while minimising whole life costs or maximising whole life value. This purpose is encapsulated in the definitions presented in Section 3.1. Levels of Service are defined as:

A statement of the performance of the asset in terms that the stakeholders can understand. They cover the condition of the asset and non-condition related demand aspirations, i.e. a representation of how the asset is performing in terms of both delivering the service to stakeholders and maintaining its physical integrity at an appropriate level. Levels of Service typically cover condition, availability, accessibility, capacity, amenity, safety, environmental impact and social equity.

- 3.2.2 Asset management enables asset managers to translate stakeholder focused goals and objectives into appropriately targeted short term work plans and schedules. Asset management does not replace existing good practice, instead it provides the framework within which this practice may be more effectively implemented, managed and complemented by other processes.

3.3 REQUIREMENTS

- 3.3.1 Asset management should be developed and implemented across asset types and organisational levels in an integrated and coordinated manner that is appropriate to the character of the transport network. As such, an authority should have asset management requirements common to all transport assets (e.g. roads, structures and lighting) and asset specific requirements derived from these. Suggested requirements for the overall transport network and specific requirements for highway structures are given in Table 3.1.

Table 3.1 - Asset Management Requirements		
ID	Transport Asset Management	Structures Asset Management
1	Goals, objectives and Levels of Service should be defined for the network and documented in the Strategic Transport Plan (e.g. LTP and LIP).	Performance targets for highway structures that align with and support the network Levels of Service should be determined.
2	An Asset Management Team (AM Team) to oversee and coordinate asset management improvements within an authority should be established. The team should be fully supported and endorsed by senior management.	A suitably qualified and committed representative for highway structures should be appointed to the AM Team. The person should coordinate asset management developments for highway structures.
3	An Asset Management Framework for the transport infrastructure should be developed, see Section 3.5. The framework should integrate asset management across asset types and organisational levels.	Processes and systems for highway structures that align with the overall framework and this Code should be developed. The processes and systems should be appropriate to the size and character of the highway structures stock.
4	A TAMP that covers all appropriate parts of the transport infrastructure should be developed, e.g. roads, structures and . lighting	An asset management planning process for highway structures that provides the necessary support information to the TAMP should be developed and implemented.
5	An Asset Management System (AMS) that fully supports the Asset Management Framework should be implemented.	A Bridge Management System (BMS) that supports the highway structures asset management planning process and aligns with the AMS should be implemented.

3.4 BASIS AND PRINCIPLES

3.4.1 The definitions provided in Section 3.1 embody the key principles of asset management. The general principles are summarised below and are consistent with those discussed in the *Framework for Highway Asset Management* [1], *PAS 55-1 Asset Management Guidance* [2] and the *International Infrastructure Management Manual* [4].

1. *Stakeholder Focused* – explicit consideration is given to stakeholder requirements in defining goals, objectives and Levels of Service, and where appropriate the public are consulted, where stakeholders include the authority/owner, public, users, community, customers, shareholders, businesses etc.
2. *Strategic* – a planned and considered approach that takes a long term view of service requirements and business objectives and uses this information to inform and appropriately target expenditure, resources and works.
3. *Integrated* – ‘joined up’ processes and decision making across **all** organisational / management levels and **all** asset types comprising the transport infrastructure.

4. *System-based* – the asset base is treated as a ‘networked system’ with emphasis on maximising the performance of the entire system.
 5. *Whole Life Considerations* – the whole life/lifecycle of the asset is considered and the whole life costs are minimised or the whole life value is maximised.
 6. *Holistic* – the best, or the most favourable, course of action(s) is selected by considering the wider economic, social and environmental impact of the action in addition to the direct impact on the service or operation.
 7. *Sustainable* – the asset base is preserved and replenished in a sustainable and cost effective way that does not impose an undue burden on future generations.
 8. *Targeted* – allocation of resources is based on a rigorous assessment of needs and benefits using prioritisation and Value Management processes.
 9. *Performance based* – the condition, functionality and other performance characteristics of the assets are measured, managed and linked to strategic goals and objectives.
 10. *Risk based* – the likelihood and consequences of asset failure or loss of performance are assessed and managed.
- 3.4.2 Many of the aforementioned principles are implicit in current highway structures management practices. Asset management brings together these principles and provides a formal framework for their implementation and use.

3.5 ASSET MANAGEMENT FRAMEWORK

Hierarchy of the management process

- 3.5.1 The management processes in large organisations can be broadly categorised into three levels: Strategic, Tactical and Operational. In many situations these levels are not well integrated which leads to a lack of consistency in decision making and goal setting, resulting in the short term work plans not delivering the long term strategic goals and objectives. An idealised hierarchy of the management process is shown in Figure 3.1.

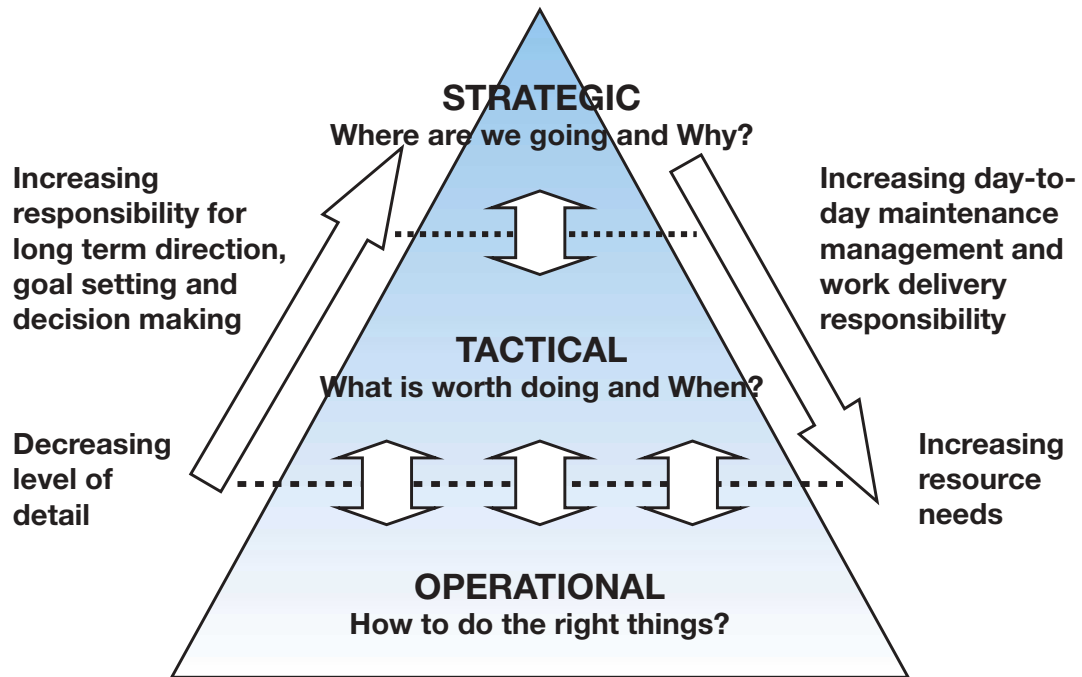


Figure 3.1: Idealised management hierarchy

3.5.2 Asset management should align with integrated planning and decision-making at the Strategic, Tactical and Operational levels. The broad scope of asset management functions in the three levels are summarised below:

1. **Strategic - Where are we going and Why?** At the strategic level the organisation should establish its overall long term direction for transport, e.g. policy, goals and objectives, vision, mission statement and targets. These goals and objectives should be agreed in consultation with stakeholders and take into account any necessary internal/external requirements and/or constraints. The strategic vision should be encapsulated within the Strategic Transport Plan (e.g. LTP and LIP) and Asset Management Policy.
2. **Tactical - What is worth doing and When?** At the tactical level the asset managers should translate the overall Strategic Transport Plan (goals and objectives) into specific plans, objectives and performance targets for the individual asset types. The tactical level should involve a performance gap analysis and a formal planning process to identify the required, most beneficial and cost effective activities and when they should be carried out. The development of a TAMP is a tactical activity.
3. **Operational - How to do the right things?** At the operational level the asset managers, engineers, technicians and operatives should develop and implement detailed work plans and schedules that have a short term outlook but take account of the work volumes and phasing arising from the TAMP. Engineering processes include inspection, structural assessment, routine maintenance, scheme design, work scheduling and implementation. Their focus is on choosing the right techniques, Value Engineering of schemes and carrying out the work in the most efficient way.

Asset management framework flowchart

3.5.3 A flowchart for a transport asset management framework is shown in Figure 3.2. The framework illustrates the stakeholder focused nature of asset management and the linkage between the Strategic, Tactical and Operational management levels. The components of the framework are discussed in the following paragraphs.

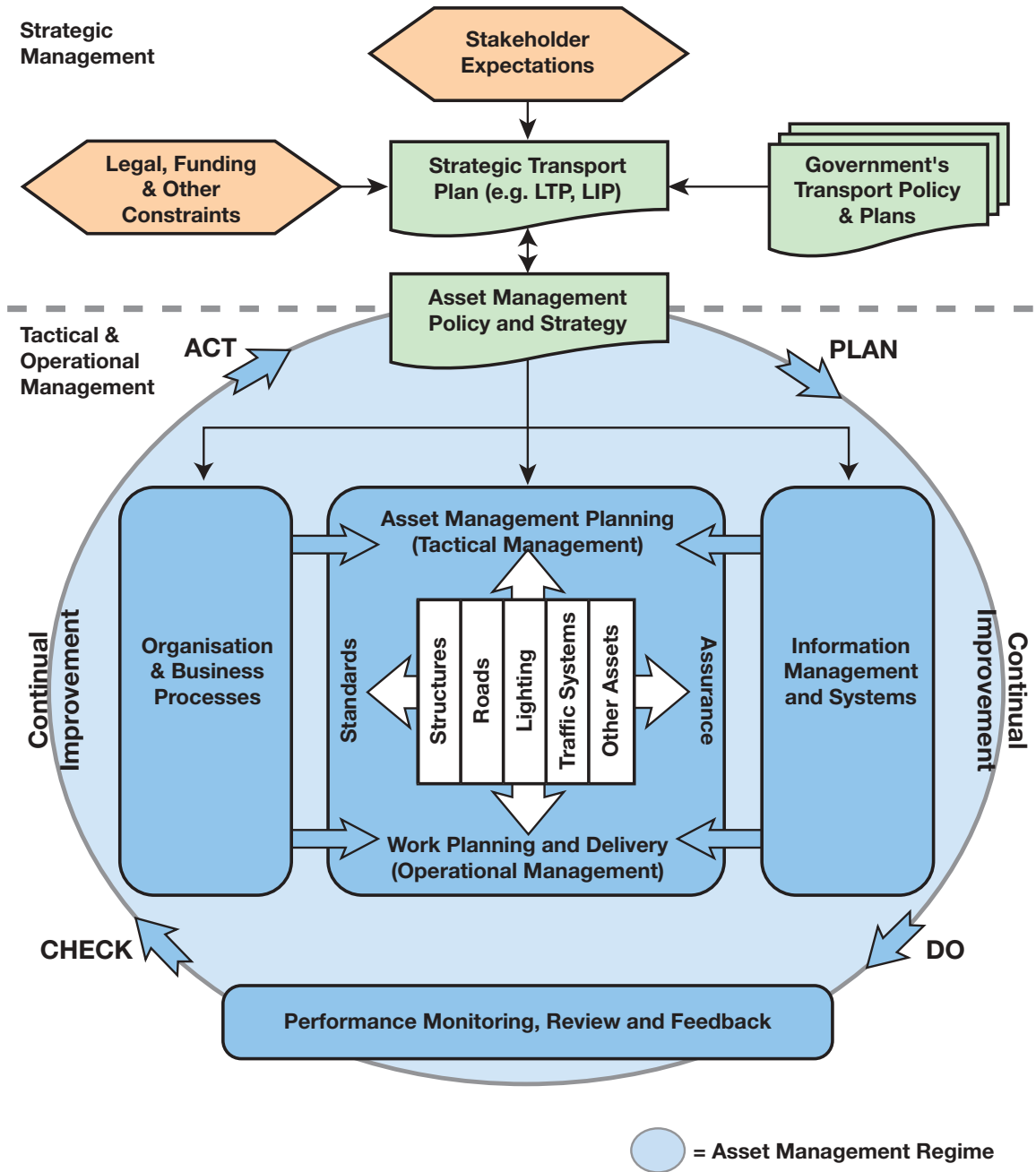


Figure 3.2: Transport Asset Management Framework

Stakeholder Expectations

3.5.4 The expectations (or demand aspirations) of the stakeholders (e.g. authority/owner, public, users, community, customers, shareholders and businesses) with regard to the transport network (e.g. condition/appearance, safety, availability, reliability etc.) are often different. All stakeholder

expectations need to be taken into account in developing the Strategic Transport Plan (e.g. LTP or LIP) and these should include the authority's goals and vision, e.g. improved tourism to be supported by improved asset condition/reliability. Surveys/consultations are normally undertaken to establish the expectations of stakeholders.

- 3.5.5 Further information on stakeholder expectations (demand aspirations) can be found in the *Framework for Highway Asset Management* [1] and the *International Infrastructure Management Manual* [4].

Strategic Transport Plan

- 3.5.6 The Strategic Transport Plan should provide the overall long term plan for the authority. The Plan should be derived from and embody the authority's vision, mission, values, business policies and objectives. Authorities may refer to this Plan as the Local Transport Plan (LTP) or Local Implementation Plan (LIP).
- 3.5.7 Generic guidance on the contents and purpose of the Strategic Transport Plan can be found in the *PAS 55 Asset Management Guidance* [2 and 3]. Specific guidance on developing an LTP and LIP are provided in *Full Guidance on Local Transport Plans: Second Edition* [5] and *Local Implementation Plan Guidance* [9] respectively.

Asset Management Policy

- 3.5.8 The Asset Management Policy should outline the intentions of an authority with regard to asset management. The Policy should provide a brief summary of why and how asset management should be used across the transport infrastructure. The Policy should be derived from and be consistent with the Strategic Transport Plan and should be endorsed by, and actively supported by, the authority's senior management.
- 3.5.9 The asset management policy should be common to all transport infrastructure assets.
- 3.5.10 Further information on the development of an asset management policy is provided in the *PAS 55 Asset Management Guidance* [2 and 3] and the *International Infrastructure Management Manual* [4].

Asset Management Strategy

- 3.5.11 The Asset Management Strategy should broadly outline the high level steps and activities for implementing the Asset Management Policy and the associated timeframe. The strategy should be derived from and be consistent with the Asset Management Policy and the Strategic Transport Plan.
- 3.5.12 The asset management strategy should be common to all transport infrastructure assets.
- 3.5.13 Further information on the development of an asset management strategy is provided in the *PAS 55 Asset Management Guidance* [2 and 3] and the *International Infrastructure Management Manual* [4].

Asset Management Regime

- 3.5.14 The Asset Management Regime (AMR) comprises the organisational structure and business processes; asset management planning and work delivery processes; and information management and systems that enable asset management to be effectively planned, implemented and delivered. Effective integration of the different components is needed for the Asset Management Regime to function effectively and efficiently. The components of the regime are summarised in the following:
1. **Organisation and business processes** – the organisational structure, roles and responsibilities, and business processes required to implement and operate the Asset Management Regime. This Code does not cover this area of the Asset Management Regime and reference should be made to the *PAS 55 Asset Management Guidance* [2 and 3].
 2. **Information management and systems** – information management, and the systems used to support it, are major considerations for all authorities due to the resources required to implement and effectively maintain them. Section 9 (*Asset Information Management*) provides guidance on the information required to support the management of highway structures and Section 10 (*Framework for a BMS*) presents functional specifications for a computerised system to support this.
 3. **Asset Management Planning and Work Planning and Delivery** – the processes used for long term asset management planning, short term work planning and delivery, and their effective integration.
 - a. **Asset Management Planning** – covers the long term (5 to 10 years) requirements for a stock of assets. Given the long timeframes considered, the analysis normally uses readily available and generic information for asset groups. Section 3.6 describes an appropriate asset management planning process for highway structures.
 - b. **Work Planning and Delivery** – covers the day-to-day management and the short term (1 to 3 year) planning, scheduling and delivery of works. At this stage individual assets are considered and the identification of needs and short term planning of work is based on the results of detailed inspections, analyses and structural assessments. Section 5 (*Maintenance Planning and Management*) describes this process in detail.
 4. **Performance Monitoring, Review and Feedback** – the performance measures used to monitor, audit and review the effectiveness of the Asset Management Regime and the plans.
 5. **Continual Improvement** – the continual improvement cycle includes the Plan, Do, Check and Act steps for improving the Asset Management Regime on a continual basis:
 - a. **Plan** - planning the work.
 - b. **Do** - doing the work.
 - c. **Check** - checking the work.
 - d. **Act** - acting upon the information to improve the process/regime.

- 3.5.15 Further information on Asset Management Regime can be found in the *PAS 55 Asset Management Guidance* [2 and 3] and the *International Infrastructure Management Manual* [4].

Transport Asset Management Plan (TAMP)

- 3.5.16 An integrated Transport Asset Management Plan (TAMP) that covers all transport infrastructure assets should be developed. In the LTP2 guidance [5] authorities are “strongly recommended” to develop a TAMP that covers the transport infrastructure.
- 3.5.17 Developing an integrated TAMP will assist authorities to integrate their transport asset management regimes across all assets. This is likely to lead to cost savings through shared development and implementation of processes, procedures, resources, tools and systems. It is the responsibility of the asset management champion and the AM team to advocate, and actively pursue, integration of transport asset management across the authority.
- 3.5.18 The output from the highway structures AM planning process (Section 3.7) contributes to the overall TAMP. The suggested content and format for a TAMP is described below. These are broadly consistent with the *International Infrastructure Management Manual* [4].
1. **Executive Summary** – should summarise the key results of the TAMP in terms of the investment required on the various asset types (i.e. road, footways, structures, street lighting, etc.) broken down by each year of the TAMP period. It should also summarise the major enhancement schemes and illustrate the spend profile for regular, programmed and reactive maintenance. It should be written and presented in a manner that is appropriate for senior management and non-technical readers.
 2. **Introduction** - should provide the background to the TAMP including purpose, relationship with other organisational documents, a summary of key roles and responsibilities and definitions of the asset types covered. The introduction should also summarise the overall goals and objectives of highway management. A brief description of each section of the TAMP and their contents should also be included. The role and contents of Strategic Transport Plan (e.g. LTP or LIP), Asset Management Policy & strategy documents should also be summarised.
 3. **Goals, Objectives, Levels of Service and Performance Targets** - should summarise the strategic goals and objectives that are relevant to the TAMP (referencing the source documents in all cases) and explain how the Levels of Service, and in turn the Performance Measures, have been derived. The historical (if available) and current Levels of Service and Performance Measure scores should be summarised and the medium/long term targets, taking account of the future demand, defined. If stakeholder surveys/consultations have been performed to establish expectations/aspirations, the results should be summarised.
 4. **Asset Base and Characteristics** – should provide a summary of the assets included in and excluded from the TAMP, providing explanations for any exclusion. The summary should include a breakdown of assets by type, group, sub-group and components. Where possible histograms should be provided for each asset type/group, etc. to describe construction or renewal dates, material types and other important asset characteristics.

5. **Future Demand** – should provide details of current and any expected changes in future network usage or demand that are likely to impact on the Levels of Service and performance required, e.g. increasing or decreasing traffic volumes.
 6. **Lifecycle Plans** – should summarise the lifecycle plans developed for each asset type, group or sub-group and the basis of their derivation, e.g. minimising whole life costs.
 7. **Work Plan** - should describe the work required to manage and operate the network at the specified Levels of Service and performance, including the difference between the current and enhanced level of performance if appropriate. The section should summarise how the work plan was developed and describe the work volumes (by asset type, group and sub-group), work type and phasing (by year of the TAMP period).
 8. **Financial Plan** - should provide details of the funding required to deliver the work plan, including the amounts needed to sustain the current and enhanced levels of performance if appropriate. The breakdown of the financial plan should align with the work types and volumes. The Plan should also include the impact of different levels of funding on network performance, whole life costs, etc.
 9. **Asset Management Improvements** – should provide details of the improvements required to the Asset Management Regime, e.g. training, people, processes, data and systems, in order to deliver the TAMP.
 10. **Risks to the Plan and their Management** – should provide details of any risks to the achievement of the plan and how they would be managed.
 11. **Monitoring, Review and Continual Improvement** - should provide details on how the TAMP performance will be monitored and the results fed back into the asset management planning process.
- 3.5.19 The asset management planning process for highway structures which provides the ‘structures’ inputs to the overall TAMP is described in the following.

3.6 OVERVIEW OF ASSET MANAGEMENT PLANNING FOR HIGHWAY STRUCTURES

- 3.6.1 This section provides an overview of asset management planning (AM planning) for highway structures. In particular, reference is made to the *Framework for Highway Asset Management* [1] and how the AM planning process for highway structures aligns with this.

Characteristics of AM planning

- 3.6.2 AM planning is a logical and systematic process for developing a Transport Asset Management Plan (TAMP). AM planning is characterised by:
1. Translation of strategic goals and objectives and Levels of Service into Performance Targets.

2. Analysis of groups of assets to determine performance gaps and identify maintenance/improvement needs. Detailed analysis of individual assets is not required for AM planning.
 3. Evaluation of the long term work volumes, phasing and associated funding needed to deliver the agreed Performance Targets. Long term is defined as a minimum of five years but preferably 10 years. This provides the 'structures' input to the authority's TAMP.
 4. A strong link between long term planning and short term work planning and delivery.
- 3.6.3 The AM planning process should be embedded within an authority's business processes and be central to the achievement of its strategic goals and objectives.

Framework for Highway Asset Management

- 3.6.4 The *Framework for Highway Asset Management* [1] provides an overview of the key steps involved in establishing an Asset Management Framework. The highway structures AM planning process presented in this Code aligns broadly with the Framework. It has been necessary, however, to refine the level of detail in order to assist explanation of each step of the process. The highway structures AM planning process is mapped to the *Framework for Highway Asset Management* [1] in Figure 3.3.

An AM planning process for highway structures

- 3.6.5 Figure 3.3 shows the long term AM planning process for highway structures. In order for this to be of benefit it must be linked to the short term maintenance planning and work delivery processes, i.e. the short term plans deliver the long term strategic goals and objectives through appropriately phased and targeted work. Figure 3.4 shows the relationship between the long term AM planning process for highway structures and the short term maintenance planning and work delivery processes. The right hand side of Figure 3.4 is expanded in Figure 5.1 and described in detail in Section 5 (*Maintenance Planning and Management*).
- 3.6.6 Section 3.7 describes the steps involved in the long term AM planning process. Documenting each step of the AM planning process and the outcomes should provide the highway structures' contribution to the TAMP. The sophistication of the AM planning process should be appropriate to the size and nature of the highway structures stock. Authorities with larger stocks may find it beneficial to automate parts, or all, of the process given the large amount of data manipulation required and the iterative nature of the planning process.

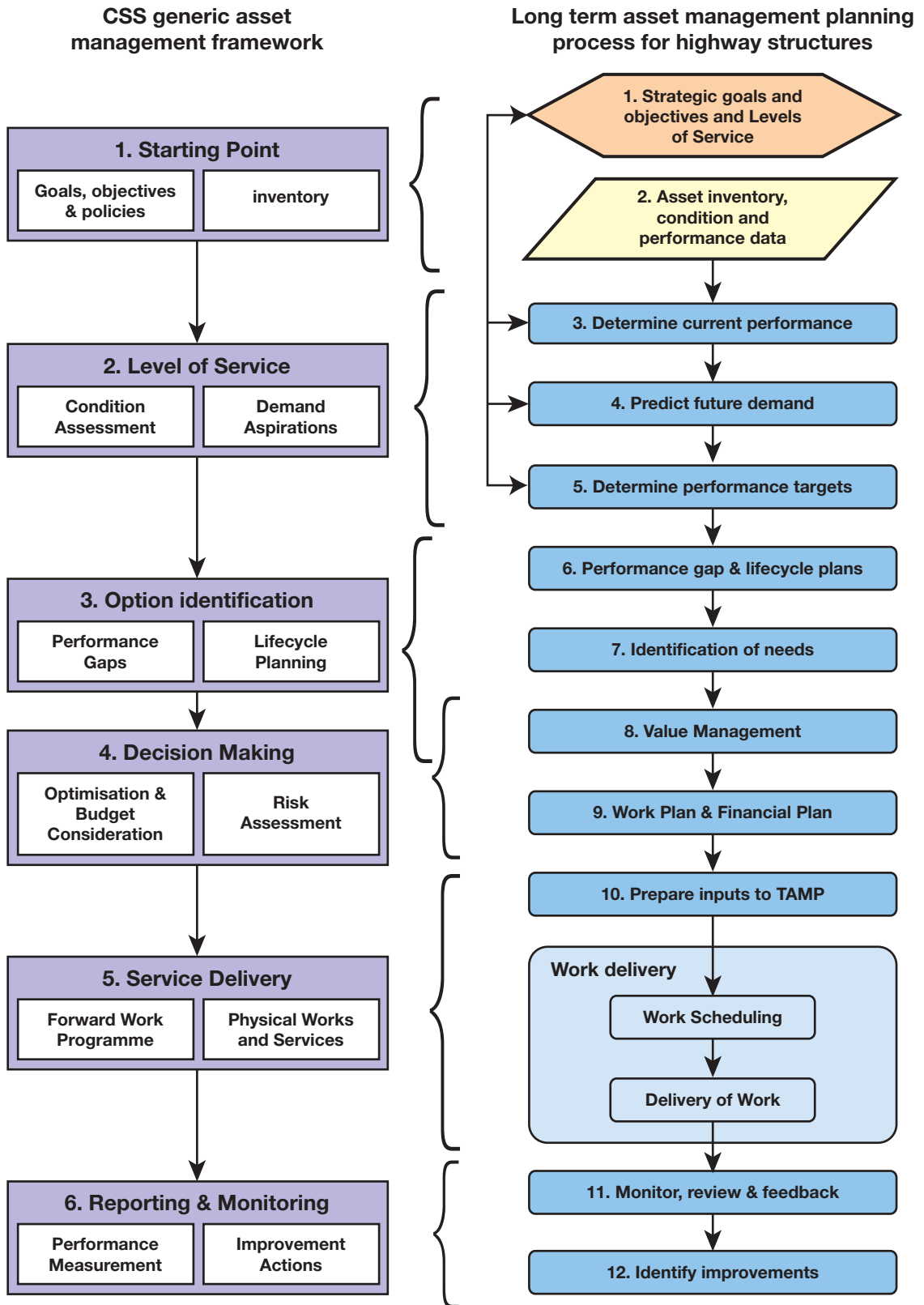


Figure 3.3: CSS Framework and Highway Structures AM planning process

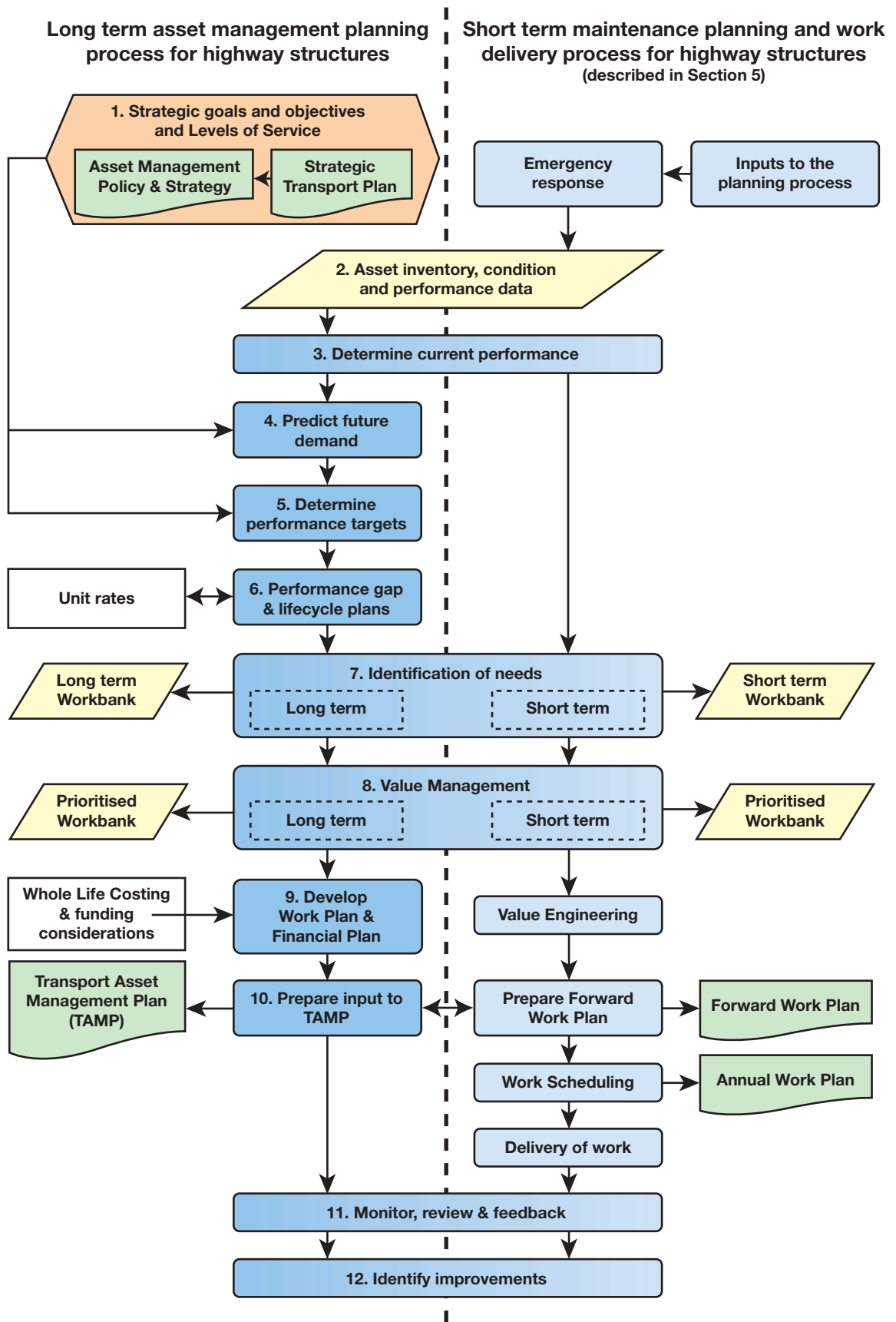


Figure 3.4: Long and short term planning processes

3.7 HIGHWAY STRUCTURES AM PLANNING PROCESS

3.7.1 The 12 steps of the long term AM planning process for highway structures shown in Figure 3.4 are described below. The purpose and outcome of each step is described and suggestions are made as to what constitutes ‘Basic AM Planning’ and ‘Advanced AM Planning’. The ‘Basic AM Planning’ should be used as an interim solution and in the longer term progress should be made towards ‘Advanced AM Planning’. In general, ‘Basic AM Planning’ should be taken to align with Milestone Two and ‘Advanced AM Planning’ with Milestone Three. Definitions for the Milestones are provided in Sections 1 and 11.

Step 1: Strategic goals and objectives and Levels of Service

3.7.2 The strategic goals and objectives should be defined in the Strategic Transport Plan and Asset Management Policy, see paragraphs 3.5.6 to 3.5.10. The strategic goals and objectives may cover criteria such as road safety, congestion, availability, journey time reliability, accessibility, condition, environmental impact and sustainability. The strategic goals and objectives are likely to be broad statements that need to be translated into quantifiable Levels of Service and Performance Targets for asset management purposes [*Framework for Highway Asset Management*; 1]; the hierarchy is shown in Figure 3.5.



Figure 3.5: Performance measurement hierarchy

3.7.3 The Levels of Service set by the authority should be reported in the Strategic Transport Plan (e.g. LTP or LIP) and summarised in the TAMP. Typically they relate to the transport network as a whole rather than to the individual asset types, i.e. highway structures. Steps 3, 4 and 5 of the planning process provide guidance on Performance Targets for highway structures and explain how these should be set to take account of the strategic goals and objectives and Levels of Service.

Basic AM Planning

- 3.7.4 The feasibility of delivering the strategic goals and objectives and Levels of Service should be assessed based on appropriate Performance Measures, available funding, past experience and engineering judgement.

Advanced AM Planning

- 3.7.5 The feasibility of delivering the strategic goals and objectives and Levels of Service should be assessed using an advanced AM Planning process and “what-if” capabilities embedded within a Bridge Management System (BMS).

Step 2: Asset inventory, condition and performance data

- 3.7.6 The asset inventory, condition and performance data provide the basic inputs for the AM planning process. Data completeness, accuracy, means of storage and retrieval have a considerable influence on the robustness and workability of the AM planning process, e.g. how readily can the information be compiled, integrated, interrogated and manipulated. Section 9 (*Asset Information Management*) and Section 10 (*Framework for a BMS*) provide guidance on the data and system requirements to support the management of highway structures including AM planning.
- 3.7.7 The stock of highway structures should be divided into groups and sub-groups that have similar characteristics, e.g. use, form, material, maintenance needs, etc. Asset groups and sub-groups are used throughout the AM planning process in order to reduce the level of detail required and to streamline the process. A general schema for grouping highway structures is shown in Figure 3.6 and explained further in Section 9. This schema aligns with the *Guidance Document for Highway Infrastructure Asset Valuation* [6].

Basic AM Planning

- 3.7.8 If the completeness and accuracy of inventory and condition data (described in Section 9) are assessed to be less than 80%, then a basic AM planning process should initially be developed and implemented. Resources should be targeted at improving data quality and completeness at the earliest opportunity.
- 3.7.9 Available data, which may be a mixture of paper and electronic, should be compiled into a user friendly format (e.g. spreadsheets) to enable some simple manipulation and interrogation. Improvements to existing systems and tools should seek to align with the core BMS functionality described in Section 10 (*Framework for a BMS*).

Advanced AM Planning

- 3.7.10 If the completeness and accuracy of inventory and condition data (described in Section 9) are assessed to be greater than 80%, then consideration should be given to developing and implementing an advanced AM planning process. Efforts should be made to improve further data quality and completeness in a gradual manner.
- 3.7.11 Data should be largely computerised enabling easy manipulation and interrogation. Advanced AM planning process should be supported by a BMS with the full functionality described in Section 10 (*Framework for a BMS*).

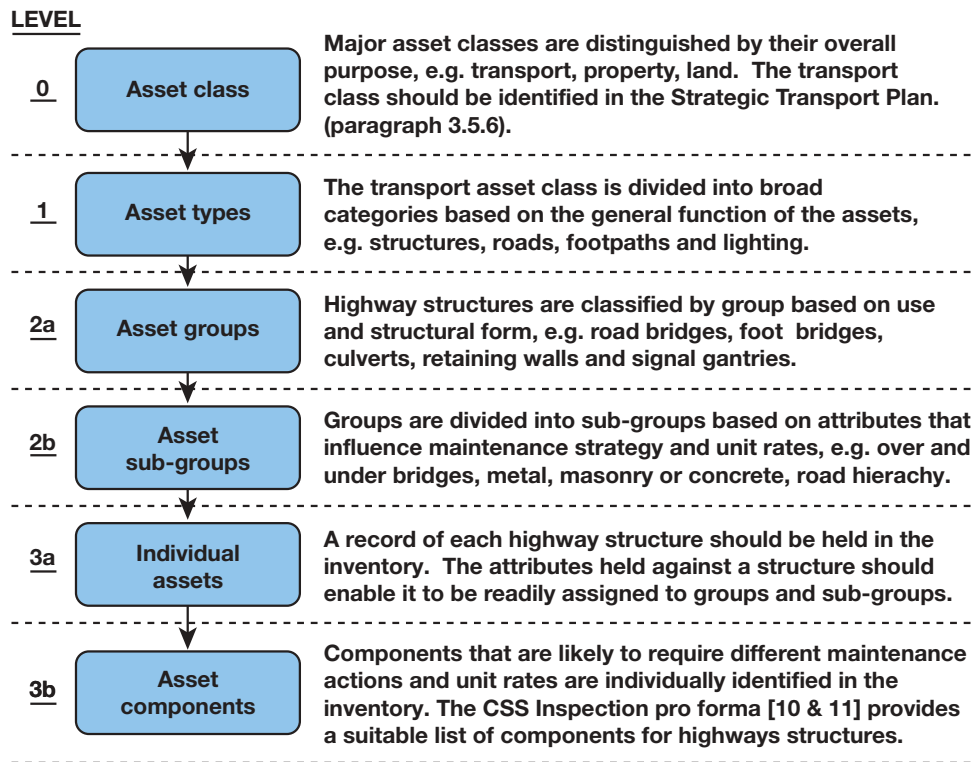


Figure 3.6: General schema for asset classification

Step 3: Determine current performance

- 3.7.12 The purpose of this step is to determine the current performance of highway structures. This establishes a basis for determining current and future maintenance needs. The current performance of highway structures should be determined for assets at Levels 1, 2a and 2b shown in Figure 3.6, although these are likely to be based on a bottom up aggregation of condition and performance, i.e. data from Levels 3a and 3b.
- 3.7.13 Guidance is provided in Section 3.8 on suitable performance measures for highway structures and on the approach that should be adopted if an authority wishes to develop additional performance measures.
- 3.7.14 The evaluation of performance measures is likely to be a substantial task in terms of data collection and compiling data into an appropriate format or system, when undertaken for the first time. Computerised systems should be considered because they can considerably reduce the effort required, especially for future evaluation of the performance measures. Historical performance should be determined, if possible, as this can assist in analysing trends and setting performance targets (Step 5).

Basic AM Planning

- 3.7.15 Analyse and determine historical and current performance, based on the condition of the structures, e.g. condition Performance Indicator (PI) and structures that do not meet current loading requirements.

Advanced AM Planning

- 3.7.16 Analyse and determine historical and current performance based on a balanced set of performance measures that represent the asset functionality and

management effectiveness, e.g. Condition PI, Availability PI, Reliability PI, Structures Workbank and Asset Value.

Step 4: Predict future demand

- 3.7.17 The performance demands placed on a transport network may change with time due to population growth, increasing/decreasing traffic volumes, changing modes of transport, increasing vehicle loads, etc. Change in demand may also arise from changes in stakeholder expectations and the authority's aspirations as reflected in changes to the Strategic Transport Plan (e.g. change of function, alternative transport, congestion charging, or planned bypass) or external factors (e.g. change in use of the obstacle crossed by a bridge). In turn, the future demand placed on the highway network should be incorporated in defining the strategic goals and objectives and Levels of Service (see Step 1). Alternative options for managing and regulating the demand as opposed to improving the network should be explored.
- 3.7.18 Changes in demand in the future may alter how a structure should be managed, e.g. if a planned route widening will necessitate a bridge replacement in 10 years time then the maintenance strategy for the existing bridge should reflect this. The most cost effective solution for the bridge may be to adopt a managed deterioration approach that provides the minimum required performance for the next 10 years but does not necessarily keep the bridge in a visibly good condition.
- 3.7.19 The prediction of future demand on highway structures should align with the network demands and are likely to include changes in vehicle weight, height and width, and traffic volume. Future demands should be predicted using available data, historical trends, and local factors. The following should be considered when developing rules for predicting future demand on highway structures:
1. **Vehicle Weight** – current highway bridge design and assessment standards [BD37, BD21] use a conservative loading model that may be able to cater for some future increases in Gross Vehicle Weights (GVW). However, increases in GVW may require associated changes to the Authorised Weight (AW) regulations, i.e. limits on axle weights, numbers and spacing. If the AW regulations change, the effect on bridges would be examined nationally and appropriate guidance provided by the DfT to highway authorities.
 2. **Height and Width** – it is unlikely that any change in specified vehicle dimension would force a national programme of bridge 'raising', road 'lowering' or road widening. It should be sufficient to assess the vertical and horizontal clearance requirements on specific structures or structures on a route, e.g. routes/structures that currently have height/width restrictions, routes that may be reclassified as a high load route.
 3. **Traffic Volume** – increases in traffic volume may require highway structures to be widened or replaced as part of a larger highway widening/upgrade scheme. Also, increases in HGV movements (for example, due to a quarry or distribution centre opening) may have a significant impact on future management and maintenance. The bridge manager should seek to obtain advance warning of such schemes and use this in AM planning.

- 3.7.20 It is likely that some of the demand predictions will not materialise due to network, socio-economic and political changes. These changes should be monitored and included in future review/revision of the TAMP.

Basic AM Planning

- 3.7.21 Predict future demand based on current knowledge of any major construction schemes, changes to HGV traffic volumes, or policy changes planned for the next five to ten year period, e.g. route widening, congestion charging, etc.

Advanced AM Planning

- 3.7.22 Supplement the basic practice with simple models that provide a more robust basis for predicting changes in system demand over a longer time horizon, say up to 30 years. These models are likely to be developed and used by transport planning staff and/or development planning staff, not the bridge manager. The bridge manager should therefore liaise with these staff to ensure information of any developments or network changes, that may effect the management of highway structures, is made available to assist AM planning.

Step 5: Determine performance targets

- 3.7.23 Future network demand (see Step 4) and stakeholder expectations (see paragraph 3.5.4) are accounted for in defining the strategic goals and objectives and Levels of Service (see Step 1). The performance targets for highway structures should be derived from, and be consistent with, the strategic goals and objectives and Levels of Service and the specific future demands for highway structures (see Step 4). The performance targets provide a focus for the AM planning process and allow better targeting of investment on highway structures to contribute to the delivery of the authority's long term goals.
- 3.7.24 A two stage approach should be used for translating strategic goals and objectives and desired Levels of Service into performance targets. First, translate them into broad statements that relate to the stock of highway structures and/or major groups within the stock, e.g.
1. Reduce the backlog of maintenance work on highway structures.
 2. Improve the overall condition of the stock of highway structures.
 3. All bridges should be capable of carrying 40 tonne vehicles.
- 3.7.25 Next, translate the broad statements into quantifiable performance targets in terms of what is to be achieved and by when, for example:
1. Reduce the backlog of maintenance from £3.5million to £1.5million by 2010.
 2. Improve the Condition Performance Indicator score from 75 to 85 by 2015.
 3. Strengthen/upgrade all structures that are sub-standard by 2010.
- 3.7.26 Where possible, it is preferable to use recognised performance measures or standards to define targets because they are based on documented procedures that are repeatable and auditable. Ideally, the performance targets, as with the performance measures, should relate to asset functionality and

effectiveness and the efficiency of the Asset Management Regime. It is suggested that the performance measures described in Section 3.8 (Condition, Availability, Reliability, Workbank and Asset Value) are used to define performance targets. Additional local performance measures may also be defined if appropriate.

- 3.7.27 Performance targets should deliver the required performance (in line with strategic goals, objectives and Levels of Service) and give due consideration to minimising whole life costs (or maximising whole life value). The latter is particularly important for highway structures because their performance, especially condition, is not of significant concern to many road users. Therefore, it is the responsibility of the bridge manager to maintain highway structures in a condition that provides best value for money, i.e. the optimum score for the Condition Performance Indicator. An advanced AM planning process is required to robustly identify, for the highway structures stock, which condition provides best value for money (see paragraph 3.7.31).
- 3.7.28 An important role of AM planning is to identify the funding required to deliver the performance targets. The bridge manager should present a robust and defensible case for the funding required. However, it should be recognised that the identified funding may not always be available. In such cases, it is important to gauge if the expected funding will deliver the performance targets, otherwise the bridge manager may be in an impossible position, being required to deliver targets that cannot be achieved with the available funding. If necessary, revised performance targets that can be delivered by the expected funding should be agreed with senior management and any implications fully explained and documented, e.g. increased whole life costs, decreased levels of performance, load restrictions.
- 3.7.29 Opportunities for sharing of information and experience in performance target setting and benchmarking with other asset managers in the authority, or with bridge managers from other authorities, should be created as this will facilitate improved understanding.

Basic AM Planning

- 3.7.30 Determine the performance targets for the next five years using engineering judgement and available information on current Condition Performance Indicator, load carrying capacity, expected funding levels, future demand and the current backlog of maintenance work. The bridge manager should decide if the condition of the highway structures stock or specific groups should improve, remain constant or be allowed to deteriorate (for structures to be decommissioned or replaced) over the five year period and make a judgement on the associated funding requirements. Based on this analysis, the five year performance targets should be defined, e.g.
1. Maintain the current Condition Performance Indicator (80) for the next five years and strengthen all sub-standard structures.
 2. Improve the Condition Performance Indicator from 80 to 82.5 over the next five years and strengthen all sub-standard structures.

Advanced AM Planning

- 3.7.31 Determine performance targets using a computerised Bridge Management System (BMS) that predicts future performance and is capable of

demonstrating the impact of different levels of funding on future performance. This involves some of the subsequent steps in the advanced AM planning process presented below and illustrates the iterative nature of advanced AM planning.

- 3.7.32 Establish performance targets for a minimum of 10 years using a balanced set of performance measures that reflect the full asset functionality and management effectiveness.

Step 6: Performance gap and lifecycle plans

- 3.7.33 The purpose of the performance gap analysis is to quantify the gap between the current performance and the target performance. Once the gap is quantified, this information can be used to develop lifecycle plans that identify the work required to close the gap and to sustain the target performance level in the future. The past, present and future performance, shown in Figure 3.7, should be determined using performance measures as given below:

1. **Past** – past performance, determined under Step 3 using historical data, should be used to establish trends that can be used to predict future performance.
2. **Present** – current performance, determined under Step 3, should be compared against the current demand and required performance. This comparison establishes the current performance gap, the work required to close this gap represents the maintenance backlog.
3. **Future** – future demand and performance targets, determined under Steps 4 and 5 respectively, and expected deterioration in performance in the future are used to assess the future gap.

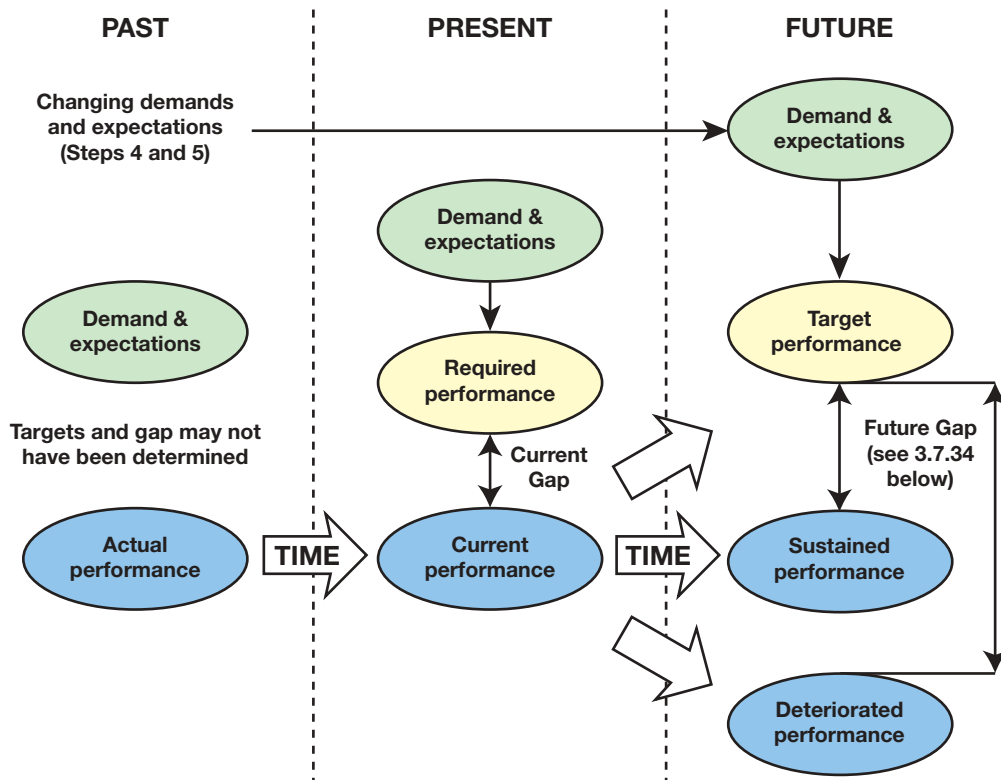


Figure 3.7: Performance gap analysis

- 3.7.34 In determining the future performance gap, three possible scenarios should be analysed:
1. **Enhancement** – the work and funding needed to enhance performance to a specified target.
 2. **Steady State** - the level of work and funding needed to sustain the current level of performance. This information is required for asset valuation purposes; see Section 4 (*Financial Planning and Resource Accounting*).
 3. **Deterioration** – the performance if funding is insufficient to maintain Steady State (if this is planned it should be referred to as **Managed Deterioration**).
- 3.7.35 Lifecycle plans should be used to analyse these scenarios. A lifecycle plan is a long term strategy for managing a group of assets with the aim of providing the required levels of performance while minimising whole life costs. Where an enhancement is required, the lifecycle plan should include: (i) the work needed to enhance the performance from the current to the required level, and (ii) the work required to sustain the enhanced level of performance. The application of lifecycle plans to identify maintenance needs is discussed in Step 7.
- 3.7.36 A lifecycle plan for a group/sub-group of structures should take into account the expected deterioration mechanisms and rates of deterioration for the material type concerned, component service lives, the required performance of assets, maintenance techniques, influence of maintenance on future deterioration rates, and maintenance unit costs. A lifecycle plan should address all stages of a highway structure's life, as shown in Figure 3.8, where:
1. **Asset creation** – covers the activities associated with the design, construction and bringing into service of the asset.
 2. **Maintenance:**
 - a. **Regular maintenance** – covers inspections, structural assessments, routine maintenance and management of sub-standard structures.
 - b. **Programmed maintenance** – preventative maintenance, component renewal, upgrading, improvements and component replacements.
 - c. **Reactive maintenance** – emergency work and essential maintenance.
 3. **Asset disposal** – disposal of the existing structure which may be followed by the creation of a new structure.
- 3.7.37 Full descriptions of the activities under regular, programmed and re-active maintenance are provided in Section 5 (Maintenance Management and Planning) and Section 5.10 provides further guidance on the development of lifecycle plans.

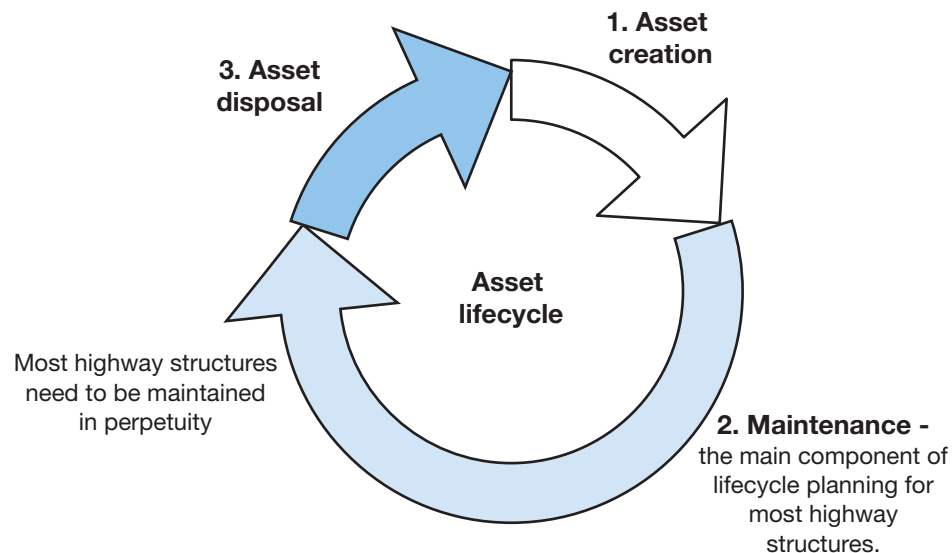


Figure 3.8: Lifecycle phases of a highway structure

3.7.38 A key part of lifecycle plans is to define optimal intervention thresholds for different types of maintenance work. These thresholds form the basis of work identification (Step 7), value management (Step 8) and work planning (Step 9). Appropriate time, effort and resources should be allocated to the development of robust and realistic lifecycle plans. Each asset group/sub-group should have a lifecycle plan relevant to sustaining the current level of performance and, if required, a lifecycle plan relevant to achieving and sustaining an enhanced level of performance.

3.7.39 The unit rates used for developing lifecycle plans should be derived from contract rates and/or project tender/outurn costs for each of the different groups/sub-groups of assets. Additional rates should be established for access, utility diversion and traffic management costs.

Basic AM Planning

3.7.40 Determine the performance gaps based on condition, e.g. the Condition PI, and load carrying capacity.

3.7.41 Develop generic lifecycle plans for each structure group, or sub-group, using engineering judgement and readily available data. The lifecycle plans should:

1. Be based on typical service lives for components such as waterproofing, bearings and expansion joints (assumed to be replaced at the same time).
2. Include regular maintenance works, e.g. inspections and routine maintenance.
3. Distinguish between exposure environments that influence the rate of deterioration and maintenance needs. It may be sufficient to identify environments as Mild, Moderate or Severe exposure based on geographical and other characteristics of the network.
4. Establish average intervals for maintenance actions such as steel painting, silane impregnation, pointing masonry, etc.

5. Establish intervention thresholds based on condition and assessed capacity for different types of maintenance action.
- 3.7.42 Identify data that should be collected to improve the accuracy of the lifecycle plans, e.g. component renewal dates, maintenance costs and quantities (project outturn data) and change in condition (to develop deterioration rates).

Advanced AM Planning

- 3.7.43 Determine the performance gaps based on a balanced set of performance measures. Improve the lifecycle plans developed under basic AM planning to take into account the additional performance measures. Use new data and expert opinion to improve the accuracy of deterioration rates, service lives, maintenance costs, etc.
- 3.7.44 Where appropriate, develop a range of lifecycle plans for groups/sub-groups to support automated “what-if” analyses of different courses of action, e.g. purely reactive strategy, sustaining current performance or enhancing performance. A computerised model (BMS) can then be used to assess the most appropriate lifecycle plan for each group/sub-group of assets.

Step 7: Identification of needs

- 3.7.45 The purpose of this step is to identify the work needed to close the performance gap, if necessary, and sustain the required level of performance. The needs are identified from the four areas of work shown schematically in Figure 3.9, where these four areas are:
1. *Work needed to sustain the current performance over the TAMP period* – use the relevant lifecycle plans developed under Step 6 and the associated intervention thresholds to identify the maintenance work needed to sustain the current level of performance over the TAMP period.
 2. *Work needed to close the performance gap* – use current condition/performance data and identify the enhancement work needed to close the gap between the current performance and the target performance.
 3. *Work needed to sustain the target performance over the TAMP period* – use the intervention thresholds from the appropriate lifecycle plans to identify the maintenance work needed to sustain the enhanced level of performance.
 4. *Work arising from other schemes planned for the TAMP period* – identify work needed on highway structures to support other schemes identified in the Strategic Transport Plan, e.g. providing ramps on footbridges to improve accessibility.

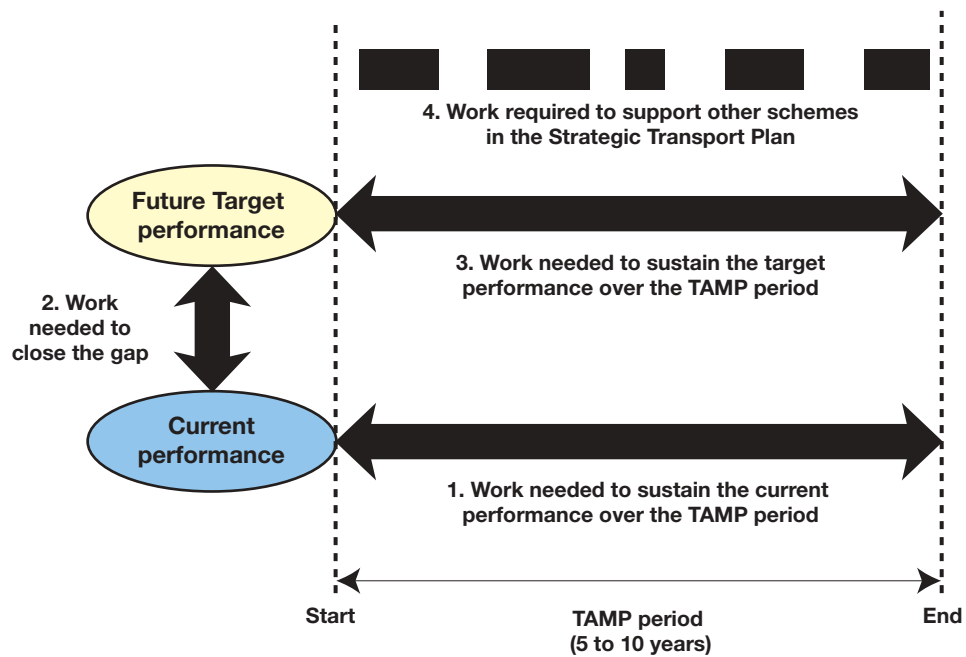


Figure 3.9: Identification of needs

3.7.46 The identified needs (i.e. the workbank) and the associated costs should preferably be in a computerised format for ease of interrogation and analysis.

Basic AM Planning

3.7.47 Identify the needs based on the four areas of work shown in Figure 3.9 using the level of sophistication developed for basic AM planning in the previous steps. Use this information to show the difference, in terms of generic work volumes and associated funding needs, between the work required to sustain the current performance and the work required to achieve and sustain the target performance. Use this information to assess the feasibility of delivering the target levels of performance given likely financial and resource constraints, and if necessary revise the target performance levels.

3.7.48 The output is a workbank that contains details of the work likely to arise over the TAMP period (5 years) and the associated costs.

Advanced AM Planning

3.7.49 Identify the needs based on the four areas of work shown in Figure 3.9 using the level of sophistication developed for advanced AM planning in the previous steps. This should be achieved through a computerised system (BMS) that enables “what-if” analyses of the following scenarios:

1. The impact of different levels of funding on the future performance, work volumes and whole life costs.
2. The impact of different performance targets on the funding requirements, work volumes and whole life costs.
3. Identification of optimum performance levels by minimising whole life costs.

- 3.7.50 This information should be used to assess the feasibility of delivering the target levels of performance given likely financial and resource constraints. Where necessary this assessment should be used to argue for, and justify, increased levels of funding/resources or, alternatively, revise the target performance levels.
- 3.7.51 The output is a workbank that contains details of the work likely to arise over the TAMP period (10 years) and the associated costs.

Step 8: Value Management

- 3.7.52 Value Management is a formalised process for assessing the benefits of undertaking maintenance and the associated risks of not undertaking maintenance and is used to prioritise the needs for work identified in Step 7. Value management enables the available/expected funding to be appropriately targeted to areas which contribute most to the achievement of the long term objectives defined in the authority's Strategic Transport Plan. At present this process is performed intuitively by most bridge managers, if not in a formalised manner, when scheduling maintenance works.
- 3.7.53 The workbank developed under Step 7 is simply a list of all the work required on the structures stock. Ideally the identified work should be carried out at the most optimal time, i.e. at the intervention thresholds defined in the lifecycle plans. In reality, however, the available funding is limited and maintenance backlogs often exist. As a result the Value Management process is used to prioritise the list of works identified in the workbank.
- 3.7.54 The Value Management process is discussed in Section 5 (*Maintenance Planning and Management*). The procedure presented in Section 5 for short term maintenance planning should also be adopted for AM planning, although a coarser level of review may be appropriate for AM planning, given the longer time frame considered and the generic nature of the works identified, e.g. lifecycle plans used for groups/sub-groups.

Basic AM Planning

- 3.7.55 Prioritise needs using condition, element importance, structure/route importance, assessed capacity and intervention thresholds identified in the lifecycle plans. The output is a prioritised workbank.

Advanced AM Planning

- 3.7.56 Develop a more robust approach to value management. Criteria, in addition to the basic AM planning, should include Availability PI and Reliability PI (see Section 3.8), structure importance (based on size, route carried, obstacle crossed, etc.) and wider socio-economic and environmental considerations. The output is a prioritised workbank.
- 3.7.57 The value management process should be built into a computerised system (BMS) as described in paragraph 3.7.49. The use of the BMS enables a more realistic analysis to be performed to take account of the impact of deferring work in terms of further deterioration of assets and the resulting increase in maintenance costs.

Step 9: Develop the Work Plan and the Financial Plan

- 3.7.58 Once the identified works are prioritised, they should be packaged into a Work Plan which can be achieved by the available/expected funding. The Work Plan provides the volume of works and the associated funding requirements for highway structures to be included in the authority's Transport Asset Management Plan (TAMP).

Basic AM Planning

- 3.7.59 The basic AM planning process is unlikely to be fully automated and as a result it is difficult to assess readily the impact of different levels of funding. Instead, Steps 7 and 8 are carried out manually giving due consideration to the available/expected funding and other constraints that may exist. The output from Steps 7 and 8 should be assessed to identify if the performance targets are achievable in the TAMP period. If not, the prudent approach may be to adopt a more conservative plan that at least sustains the current performance.
- 3.7.60 The work volumes and funding should be planned, by year, across the TAMP period, preferably for five years. This should be consistent with the Forward Work Plan described in Section 5 (*Maintenance Planning and Management*). Consideration should be given to achieving a sustainable programme of work and relatively uniform levels of funding, although higher levels of funding may be appropriate in the early years to remove maintenance backlog.

Advanced AM Planning

- 3.7.61 Steps 2 to 8 of the advanced AM planning process should be automated and form an integral part of the Bridge Management System. The "what-if" capability described under Steps 7 and 8 should be used, along with Whole Life Costing (WLC) and optimisation algorithms, to determine a cost effective and sustainable work plan. The optimisation, in addition to that already implicit in the lifecycle plans, should seek to identify cost savings by packaging works by route, structure type and/or work type.
- 3.7.62 The work volumes and funding should be planned, by year, across the TAMP period, preferably for 10 years. The "what-if" functionality enables a wide range of constraints to be introduced into the AM planning process and enables a number of iterations to be readily performed. The bridge manager should use this capability to justify, through a repeatable and auditable process, the most appropriate performance targets and funding for highway structures.

Step 10: Prepare input to TAMP

- 3.7.63 Working through the AM planning process provides the information for highway structures that is input to the TAMP.
- 3.7.64 The typical contents of a TAMP are summarised in Section 3.5. The contents should be discussed and agreed with the AM team to identify the likely input required for highway structures.

Basic AM Planning

- 3.7.65 The work volumes and costs derived from the basic AM planning process are provided for the TAMP. There is likely to be only one set of Work Plan/Finance Plan information available since only one scenario is analysed.

Advanced AM Planning

- 3.7.66 The work volumes and costs derived from the advanced AM planning process are provided for the TAMP. Different sets of Work Plan/Financial Plan information may be available corresponding to different funding scenarios. If necessary, these can be further refined to benefit from synergies of combining highway structures maintenance with work on other highway assets (see Sections 5.12 to 5.14).

Step 11: Monitor, review and feedback

- 3.7.67 The AM planning process produces a work plan that is expected to deliver a defined set of performance targets in a specific time frame. There is a degree of uncertainty in the plan, the magnitude of which depends on the robustness and reliability of the AM planning process. There is consequently no guarantee that the TAMP will actually deliver the performance targets. A process for regular monitoring and review should be implemented and feedback provided to the AM planning process. The monitoring and review process should include a comparison of the planned vs actual work performed on different asset groups and the resulting performance improvements achieved.
- 3.7.68 Updating the asset inventory, condition, maintenance and cost information regularly allows the performance measures to be calculated and compared against the targets. Updating enables timely corrective action to be taken if the TAMP is not delivering the targets.

Step 12: Identify improvements

- 3.7.69 The bridge manager should continually seek to improve the efficiency and effectiveness of the AM planning process. Improvements should be identified on a continual basis and be recorded in the AM Strategy. The bridge manager should prioritise improvements in agreement with the AM team in order to prevent duplication of effort across asset types, e.g. roads and structures. The improvements should enable the authority to progress from the basic to the advanced AM planning process.
- 3.7.70 In addition to implementing improvements to the processes and tools, the following should be considered:
1. Improvements to data quality and completeness.
 2. Improved accuracy of the lifecycle plans.
 3. Additional performance measures that will improve the understanding of the performance of the structures stock and effectiveness of the Asset Management Regime.

3.8 PERFORMANCE MEASUREMENT FOR HIGHWAY STRUCTURES

Introduction to performance measurement

- 3.8.1 Performance measurement is a mechanism through which an authority can determine how effective the Asset Management Regime has been and how the assets are currently performing, e.g. the condition of the highway structures stock. Performance measurement should be used to inform the authority, and external parties, about how performance compares against predefined goals,

objectives and performance targets over time. Performance measures should align with and support the strategic goals and objectives. Performance measurement is acknowledged as a fundamental and central component of effective asset management planning, monitoring, review and continual improvement. Performance measurement is central to the government's commitment to modernisation and improvement which is recognised in the government paper *Choosing the Right Fabric: A Framework for Performance Measurement* [12].



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- 3.8.2 The performance measures chosen should represent the different aspects of asset functionality and their condition. In addition performance measures should aim to measure the effectiveness and efficiency of the planning and delivery processes. It is preferable to use a small but balanced set of performance measures that have the biggest impact on the achievement of strategic objectives. This reduces the complexity of the AM planning process and the data required.
- 3.8.3 The following should be considered when identifying performance measures for use in AM planning:
1. Performance measures for highway structures that are already in use, e.g. Condition PI.
 2. Performance measures that have been developed, or are under development, for highway structures, e.g. Availability and Reliability PI, see below.
 3. Additional performance measures that may be needed to reflect the Levels of Service for the overall network and for measuring the effectiveness and efficiency of the planning and delivery processes.
- 3.8.4 The Government paper on *Choosing the Right Fabric: A Framework for Performance Measurement* [12] provides useful further guidance for the identification, development and use of performance measures.

Suggested performance measures for highway structures

- 3.8.5 A set of four performance measures has been developed [*Performance Measures for Highway Structures*, 13] that cover asset functionality and management effectiveness of highway structures. The measures are:
1. **Condition Performance Indicator** – a measure of the physical condition of the highway structure stock (measured on a scale of 0, worst, to 100,

best). The Condition Performance Indicator is also referred to as the Bridge Condition Indicator, BCI [CSS *Bridge Condition Indicator Volume 3*, 14; *Addendum to CSS Bridge Condition Indicator Volume 3*, 15]. The Condition Performance Indicator is evaluated from the condition rating (severity and extent) recorded for each element on the structure.

2. Availability Performance Indicator – a measure of the reduction in the availability provided, on a highway network, due to restrictions on the use of highway structures (measured on a scale of 0, worst, to 100, best).
3. Reliability Performance Indicator – a representation of the ability of the structures stock to support traffic, and other appropriate loading, taking into account the consequence of failure (measured on a scale of 0 worst, to 100 best). The Reliability Performance Indicator uses a risk based approach that combines the probability of failure and the consequences of failure.
4. Structures Workbank – the cumulative cost of all work identified and arising from Step 7 of the AM planning process (the Workbank is the monetary value of the works identified). The Structures Workbank is an important measure because it demonstrates in monetary terms the increasing cost of work required if the other three performance measures are allowed to decline.

3.8.6 The above four performance measures were identified by a national consultation group as representing the most important measures in relation to the objectives and strategic functions of the management of highway structures. The guidance documents [13] were released as Draft Working Reports in February 2005, with a 12 month consultation period. The performance measures are scheduled to be reviewed in February/March 2006 based on the feedback received.

3.8.7 The performance measures described above should be adopted if appropriate for the authority's highway structures stock. These measures may be augmented with additional Local Performance Measures where appropriate, e.g. "number of General Inspections performed each year" and "number of substandard structures".

3.8.8 Asset Value should also be considered as a potential performance measure. Asset Valuation is described in Section 4 (*Resource Accounting and Financial Planning*).

Performance measurement data

3.8.9 The Good Management Practice described in this Code provides the majority of the data required for producing the above performance measures. Data collection for the sole purpose of performance measurement is to be discouraged as it represents an ineffective use of resources. The above four performance measures were developed to utilise the majority of the data required for other management processes, e.g. assessed capacity, structure dimensions, element condition, and restrictions.

Evaluating performance measures

3.8.10 Performance measures should be evaluated using a 'bottom-up' approach, i.e. from individual component or structure level to stock level. A 'bottom-up'

approach means the performance measures are based on real data from individual structures and represent the actual situation on the ground. The 'bottom-up' approach also allows results on groups of structures to be assembled together in a variety of ways and the performance measures evaluated for these groups. The aforementioned performance measures (Condition, Availability, Reliability and Workbank) use a 'bottom-up' approach.

- 3.8.11 The calculation of performance measures for all highway structures is a considerable task and not suitable for hand calculation. Implementation of computerised tools (within a BMS) that automatically perform the calculations should be considered. Computerised systems also enable the bridge manager readily to manipulate the data for measuring, monitoring and auditing performance at different group and sub-group or functional unit levels and to use the information to target improvement actions.

Performance reporting

- 3.8.12 There are already external requirements on authorities to produce performance reports. The Annual Best Value Performance Plan requires such reports (see paragraph 2.4.1), and one of the key elements of LTP2 is that it will contain indicators and trajectories for performance reporting via the Annual Progress Report (see paragraph 2.3.4).
- 3.8.13 Some authorities may be required to produce additional annual or quarterly performance reports to inform internal management and control, and possibly for external reporting to auditors and the public.
- 3.8.14 *Performance Measures for Highway Structures: Part A* [13] provides guidance on performance reporting. Important points to consider when producing a report are:
1. Define a format and retain it for subsequent reports. Internal management and external bodies should be able easily to compare the current performance with previous performance. The format should also describe the scope and the level of detail that the reported performance measures relate to, e.g. what groups within the structure stock are selected for presentation.
 2. Use easily understood graphs, diagrams and statistics to explain the performance of the structures. Histograms are very effective at showing the spread of performance measures within a stock or group of highway structures.
 3. Explain changes in higher level performance measures using groups and sub-groups.
 4. Seek views from others in the authority about the clarity and ease of understanding of the report.

3.9 RECOMMENDATIONS

- 3.9.1 The recommendations for structures asset management planning are:
1. An Asset Management Regime should be developed for highway structures that is appropriate to the size and character of the stock. The regime should seek to be consistent with those for other transport assets.

2. A highway structures representative should be appointed to the authority's asset management team.
 3. A robust long term asset management planning process should be developed and implemented for highway structures.
 4. Performance measures and targets should be established for highway structures which align with and support the strategic goals and objectives and Levels of Service.
- 3.9.2 A Bridge Management System (BMS) should be implemented that supports AM planning, and where possible the BMS should be part of, or align with, the wider Transport Asset Management System. Refer to Section 10 (*Framework for a BMS*) for recommendations and actions associated with the development and implementation of a BMS that supports the management of highway structures, including AM planning.
- 3.9.3 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Nominate a highway structures representative to the asset management team (Section 3.3).
TWO	<ul style="list-style-type: none"> • Determine the content and scope of the Asset Management Regime that is appropriate for the authority's highway structures stock and align the Regime with the regimes for other transport assets (Section 3.5). • Translate strategic goals and objectives and Levels of Service into performance targets for highway structures (Section 3.7). • Identify the components of the Asset Management Regime that need to be developed for Basic and Advanced AM Planning (Section 3.7). • Develop and implement components of the AM Regime needed to deliver the Basic AM Planning process for highway structures (Section 3.7).
THREE	<ul style="list-style-type: none"> • Develop and implement components of the AM Regime needed to deliver the Advanced AM Planning process for highway structures (Section 3.7).

3.10 REFERENCES FOR SECTION 3

1. *Framework for Highway Asset Management*, County Surveyors Society, April 2004.
2. *PAS 55-1 Asset Management: Part 1: Specification for the optimized management of physical infrastructure assets*, The Institution of Asset Management and BSI, 2004.
3. *PAS 55-2 Asset Management: Part 2: Guidelines for the application of PAS 55-1*, The Institution of Asset Management and BSI, 2004.
4. *International Infrastructure Management Manual*, UK Edition, 2003.

5. *Full Guidance on Local Transport Plans: Second edition*, Department for Transport, December 2004.
6. *Guidance Document for Highway Infrastructure Asset Valuation*, County Surveyors Society, The Stationery Office, July 2005.
7. *The Prudential Code for Capital Finance in Local Authorities*, CIPFA, 2003.
8. *The Local Government (Best Value) Performance Plans and Reviews Amendment and Specified Dates Order 2002*, Statutory Instrument: 2002 No 305 Local Government, England and Wales, HMSO.
9. *Mayor's Transport Strategy – Local Implementation Plan Guidance*, Transport for London, July 2004.
10. *Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting*, County Surveyors Society, 2002.
11. *Addendum to CSS Bridge Condition Indicator Volume 2*, County Surveyors Society, 2004.
12. *Choosing the Right Fabric: A Framework for Performance Information*, HM Treasury, Cabinet Office, National Audit Office, Audit Commission, Office for National Statistics, March 2001.
13. *Guidance Document on Performance Measures for Highway Structures, Parts A, B & C*, Highways Agency and County Surveyors Society, Version 1.3, February 2005, www.cssnet.org.uk.
14. *Bridge Condition Indicators, Volume 3: Guidance Note on the Evaluation of Bridge Condition Indicators*, County Surveyors Society, July 2002, www.cssnet.org.uk.
15. *Addendum to CSS Guidance Note on Bridge Condition Indicators, Volume 3: Guidance Note on the Evaluation of Bridge Condition Indicators*, County Surveyors Society, August 2004, www.cssnet.org.uk.

Section 4

Financial Planning and Resource Accounting

This section provides guidance on financial planning and resource accounting for highway structures. Different levels of financial planning, from short term budgets to long term Transport Asset Management Plans are described. The principles and requirements of Resource Accounting are introduced, and capitalisation policy and classification of expenditure on highway structures is discussed. The asset valuation process for highway structures and the calculation of commuted sums are summarised.

4.1 INTRODUCTION

- 4.1.1 The introduction of Whole of Government Accounts (WGA) from 2006-07 covers the entire public sector including central government departments, local authorities, NHS trusts and other public bodies.



- 4.1.2 The WGA presents a comprehensive picture of the public finances prepared on a basis comparable with that of the private sector. This will provide useful information for fiscal policy-making and the planning and management of public finances and services. WGA is intended to improve Government's accountability to Parliament and tax payers, and forms an important element of the Modernising Government agenda.
- 4.1.3 The WGA builds on the Prudential system [1] for local government finance and the Resource Accounting procedures for central government. WGA uses accruals accounting methods in line with the Generally Accepted Accounting Practice (GAAP).
- 4.1.4 To enable the compilation of WGA all government bodies need to produce the accounts on a consistent basis. It is recognised that there are some differences in the guidance currently available to local authorities and central government departments for accounting. These differences are likely to reduce over the coming years.

- 4.1.5 It should also be recognised that highway structures form only one part of the transport infrastructure and other services managed by an authority. Accounting principles and practices should be consistent across all the operations of an authority and should be agreed with its auditors.

4.2 PURPOSE

- 4.2.1 A sound process for **financial planning** is critical to the management of highway structures since it forms the basis for securing the necessary funds and in setting the budgets. Financial planning also ensures that the available funding is appropriately targeted and effectively spent for the maintenance of highway assets.
- 4.2.2 The purpose of **resource accounting** is to reflect the full cost of ownership and use of highway assets in delivering transport services to the public. An important component of resource accounting is producing the Statement of Accounts. The objective of the Statement of Accounts is to provide information about an authority's financial performance and position that is useful for assessing the stewardship of public funds and for making economic decisions.
- 4.2.3 The Statement of Accounts typically contains several financial statements which present the financial performance and position during the accounting period covering the authority's assets, liabilities, income and expenditure, the cash flow, and any provisions for the future. The guidance in this Code is limited to matters relevant to highway structures.
- 4.2.4 **Asset valuation** is a key requirement of resource accounting. It provides a monetary value of the highway assets to be included in an authority's Balance Sheet. Asset Valuation also provides a measure of depreciation of highway structures representing the consumption of the assets in delivering services to the public.

4.3 REQUIREMENTS

- 4.3.1 Financial plans should be prepared covering short, medium and longer term periods for the maintenance of highway structures. The plans should provide the basis for targeting investment in achieving the authority's Strategic Transport Plan, e.g. LTP or LIP.
- 4.3.2 Appropriate policies and procedures should be implemented for the accounting of expenditure on highway structures in accordance with financial reporting standards, established accounting practices and guidance.
- 4.3.3 Appropriate policies and procedures should be implemented for the asset valuation of highway structures for inclusion in the authority's Balance Sheet. The valuation should follow financial reporting requirements and guidance provided in *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2].

4.4 BASIS AND PRINCIPLES

Financial Planning

- 4.4.1 Financial plans for highway structures should be prepared to cover short, medium and longer term periods as an integral part of the asset management planning process described in Section 3 (*Asset Management Planning*).
- 4.4.2 The financial plans should provide a robust justification for investment in the maintenance of highway structures, i.e. the investment needed to protect safety and function in meeting current and future traffic demand. The consequences of any shortfall in funding should be properly represented to aid decision making by the funding bodies.
- 4.4.3 The financial plans should be prepared by incorporating the principles of best value, whole life costing, and sustainability. The plans should aim to achieve the longer term service goals and performance targets set out in the authority's Strategic Transport Plan at minimum whole life costs.

Resource Accounting

- 4.4.4 Resource accounts are intended to represent the full cost of ownership and use of assets in delivering transport services to the public. For this reason, the financial statements prepared should aim to provide a systematic link between services delivered and resources consumed in the accounting period.
- 4.4.5 The financial statements should be prepared on an accruals basis in which the transactions (expenditure on assets and consumption of their benefits) are represented in the accounting period when the transactions are experienced and not in the period when any cash is received or paid out.
- 4.4.6 In addition, the financial statements should be prepared to incorporate established accounting principles, including:
1. *Reliability* – the information contained can be depended upon for the stated purpose; it is free from deliberate or systematic bias; it is free from material error; and it has taken a prudent approach in dealing with uncertainty.
 2. *Comparability* – the information provided can be compared with similar information about the authority for previous accounting periods and with other similar authorities. It depends on consistency and adequate disclosure.
 3. *Materiality* – all information is included that might be expected to have an influence on the purpose for which the financial statements are used. Materiality depends on the size and nature of the item considered and should be judged on the circumstances of the case.

Asset Valuation

- 4.4.7 Highway structures are non-commercial assets and hence should be valued on the basis of Depreciated Replacement Cost as required by accounting standards [*Financial Reporting Standard 15*; 3].

- 4.4.8 Valuation may be based on 'modern equivalent asset' where the existing form of the asset is technologically obsolete and is most likely to be replaced with a modern equivalent. Replacement in this way may not apply to heritage or listed structures.
- 4.4.9 The depreciation of assets should as accurately as possible represent their loss in service potential with time. Any sudden drop in service potential should be recognised as an impairment loss.
- 4.4.10 The valuation of assets should also incorporate the principles of *Reliability, Comparability and Materiality* as mentioned above.

4.5 FINANCIAL PLANNING AND BUDGETING

Hierarchy of Financial Plans

- 4.5.1 Financial plans for highway infrastructure assets should be prepared in three levels in an integrated manner:
 1. Long Term Transport Asset Management Plan (TAMP) – the TAMP presents both a Work Plan (listing of all maintenance, renewal and upgrade works to be completed and their phasing over the duration of the plan) and a Financial Plan which gives the required investment profile over the period. The TAMP should cover a period of preferably 10 years or longer divided into 5 year periods. The Plan should present the longer term investment in highway structures needed to protect the safety and function of the highway network in meeting the current and future traffic demand. It is recommended that the Transport Asset Management Plan is updated at least once every 5 years.

The TAMP can also be used by highway authorities to support their capital investment plans as recommended by *The Prudential Code for Capital Finance in Local Authorities* [1].
 2. Medium Term Financial Plan – should cover a period of 3 to 5 years and should closely align with the authority's bid for funds, e.g. as part of the LTP (Local Transport Plan) process for local highway authorities in England and Spending Reviews for trunk road authorities. The Medium Term Plan should be updated annually on a rolling basis. The Medium Term Plan should be guided by the long term TAMP and in turn should feed into it.
 3. Annual Financial Plan – should cover one financial year and should be closely aligned with the authority's annual budgeting process. This Annual Plan should include all the works planned to be undertaken during the year. The Annual Plan should be guided by the Medium Term Plan and in turn should feed into it.

Development of Financial Plans

- 4.5.2 The detailed process for developing the highway structures input to the TAMP is given in Section 3 (*Asset Management Planning*).
- 4.5.3 The Medium Term Financial Plan should be based on the Forward Work Plan (see Sections 3 and 5) covering a period of 3 to 5 years; updated annually.

- 4.5.4 The Annual Financial Plan should be derived from the Annual Work Plan, which is a schedule of works to be completed during a financial year (see Section 5). The Annual Plan should cover all maintenance needs identified and prioritised through a Value Management process and developed into detailed schemes of work through the Value Engineering process (see Section 5 for details). It should also include an allowance for emergency and unforeseeable work.
- 4.5.5 In order to provide the link between performance targets and investment needs, all the financial plans should preferably be broken down into three levels by:
1. Road hierarchy (e.g. Trunk, Principal, Non-principal Classified, and Unclassified);
 2. Structure type (e.g. bridges, retaining walls, tunnels, etc.).
 3. Maintenance type (see Section 5.5).

Business Case for Funding

- 4.5.6 Financial Plans are prepared to inform the planning and management of an authority's operations. Financial Plans also form a basis for bids to the relevant funding body.
- 4.5.7 In order to secure the necessary funds for highway structures, it is important that a robust business case is made for the investment needs. The case should be supported by including appropriate information on highway structures in the TAMP, which is prepared as described in Section 3 (*Asset Management Planning*).
- 4.5.8 In addition, it is suggested that the consequences of under funding by say 10%, 20% and 30% should be presented in terms of:
1. Impact on the highway network – evaluated in terms of traffic disruption, socio-economic and environmental effects caused by possible restrictions on highway structures and the potential political repercussions of this.
 2. Impact on asset health – evaluated in terms of the likely drop in values of Performance Indicators (PIs) for Condition, Reliability and Availability (see Section 3.8).
 3. Impact on sustainability – evaluated in terms of the increase in the Structures Workbank (see Section 3) and the loss in asset value of the structures stock.
 4. Economic impact – evaluated in terms of the increase in whole life costs relative to the bid.
- 4.5.9 This information helps the decision making process for allocation of funds since it considerably strengthens the business case for investment in the maintenance of highway structures.

Budgets

- 4.5.10 Once the allocations for the maintenance of highway structures have been decided, the allocations form the basis for the budgeting process.
- 4.5.11 Different highway authorities follow different budgeting cycles. Currently, most highway authorities follow an annual budgeting cycle but in recent years there has been a trend towards 3 yearly or 5 yearly budget cycles.
- 4.5.12 Trunk road authorities at present follow a 3 year budget, called the Departmental Expenditure Limit (DEL), which remains fixed for the 3 year period.
- 4.5.13 Under Resource Accounting and Budgeting procedures, resource accounts and hence budgets should reflect the true and full costs to a highway authority of delivering services to its customers. For this reason items such as depreciation and impairment of infrastructure assets form part of an authority's budget and are treated in the same way as direct expenditure on maintenance and renewal. It is therefore necessary to estimate costs for these items accurately and to include them in the funding bids and budgets.

4.6 RESOURCE ACCOUNTING

Accounting for Structures Expenditure

- 4.6.1 Resource accounts in relation to highway structures are intended to represent the full cost of ownership and use of these assets. An authority's Statement of Accounts should aim to provide a systematic link between the resources consumed and the delivery of services to users.
- 4.6.2 Guidance for local authority accounting is contained in the CIPFA/LASAAC *Code of Practice on Local Authority Accounting in the United Kingdom 2004 – A Statement of Recommended Practice (SORP)* [4]. Trunk road authorities follow the *Resource Accounting and Budgeting (RAB)* procedures contained in the HM Treasury's *Resource Accounting Manual (RAM)* [5]. In addition, an authority may have its own accounting rules and practices which are agreed with the auditors; and these should also be followed.
- 4.6.3 The cost of use of the assets can be broadly categorised into:
 - 1. Direct Capital expenditure (Capex);
 - 2. Direct Operating expenditure (Opex);
 - 3. Depreciation of assets;
 - 4. Impairment of assets;
 - 5. Capital finance charge (currently at 3.5% of asset value, but this may not apply to local highway authorities).
- 4.6.4 Guidance on the classification of various items of expenditure on structures assets into Capex and Opex is given below. The evaluation of capital charge, depreciation and impairment is addressed in Section 4.7.

Capitalisation of Costs

- 4.6.5 The capital expenditure of local highway authorities is funded typically by a capital allocation from the Government while operating expenditure is funded generally by the revenue allocation from the authority's own sources. In some cases, funding for some non-capital works (e.g. 'Safe Routes to Schools' schemes) is also funded through capital allocation. The focus here is on how an item of expenditure on highway structures should be treated in preparing the Statement of Accounts regardless of the source of its funding. To avoid confusion, the terms 'Capital Expenditure' (Capex) and 'Operating Expenditure' (Opex) are used in the following.
- 4.6.6 All expenditure on the acquisition, creation, enhancement or replacement of highway structures, or parts thereof, should be capitalised on an accruals basis, provided that the expenditure yields benefits to the authority and the services it provides are for a period of more than one year.
- 4.6.7 In the above context, enhancement means the carrying out of works which are intended to:
1. Lengthen substantially the useful life of the asset; or
 2. Increase substantially the standard of performance or service potential of the asset.
- 4.6.8 Expenditure on existing assets should be capitalised in three circumstances (as defined by the SORP [4] and the RAM [5]):
1. The expenditure enhances the asset as defined in 4.6.7 above.
 2. Where a component of the structure (for example bearings, joints, etc), that has been treated separately for depreciation purposes, is replaced or restored at the end of its useful life.
 3. Where the expenditure relates to a major inspection or overhaul of an asset (for example overhaul of the mechanical equipment in a movable bridge) that restores the benefits of the asset that have been consumed by the authority and have previously been reflected in depreciation.
- 4.6.9 Based on the above, a decision-tree is shown in Figure 4-1 to help the decision on whether an item of expenditure may be classified as Capex or Opex.

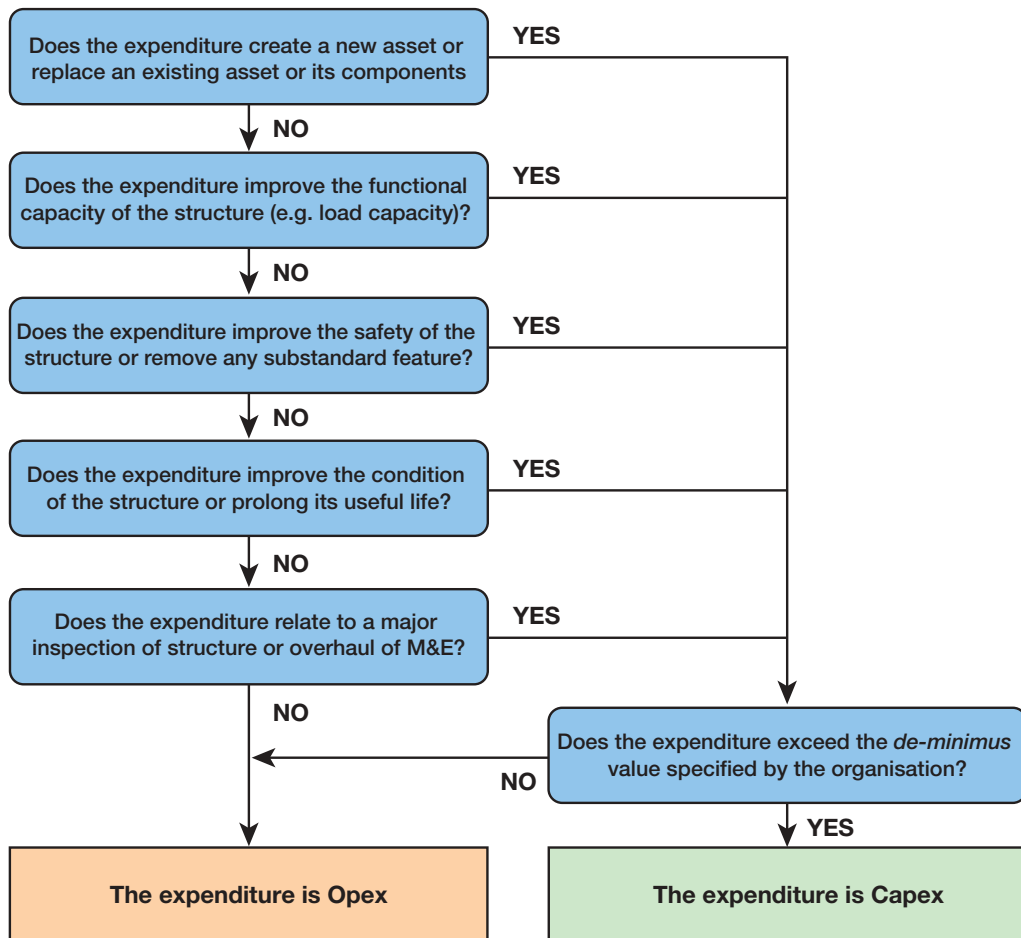


Figure 4.1: Decision-tree for capitalisation of structures expenditure

4.6.10 On a new build or an improvement scheme only those costs that are directly attributable to the construction of an asset(s) are usually capitalised. Indirect costs not directly related to the scheme, e.g. overall programme management costs or financial monitoring costs are not usually Capex. The authority’s own staff time, overheads and consultancy costs directly attributable to a specific scheme, for example, are usually Capex. However, activities that take place before the intention to construct a specific asset and some of the preparatory costs are generally regarded as Opex.

4.7 ASSET VALUATION

Valuation Basis

4.7.1 The purpose of asset valuation is to produce a monetary value of highway structures to be included in an authority’s Balance Sheet. It also provides a measure of depreciation of highway structures which represents the consumption of the assets in delivering services to the public. Asset valuation is important for demonstrating proper stewardship of public assets and is a key requirement for producing Whole of Government Accounts.

4.7.2 Highway structures are largely publicly owned and have rarely if ever been sold on the open market. These assets are not created or used primarily for the purpose of revenue generation and hence market value-based or revenue stream-based valuation methods are not appropriate.

- 4.7.3 Requirements for valuation are contained in HM Treasury's Resource Accounting Manual (RAM) [5] which, in line with the requirements of *Financial Reporting Standard 15 - Tangible Fixed Assets (FRS 15)* [3], recommends that highway infrastructure assets are valued on the basis of Depreciated Replacement Cost, where this is taken as *the current replacement cost depreciated to reflect the overall condition of the network*.
- 4.7.4 Where an authority adopts a policy of revaluation, highway structures should be subject to a full revaluation once every 5 years. In between revaluations, the valuations can be adjusted using appropriate price indices.
- 4.7.5 The detailed procedure for the valuation of highway assets, including structures, is given in the *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2], which should be followed. The guidance is summarised below.

Valuation Process

- 4.7.6 Detailed guidance for each of the steps in the valuation process can be found in the *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2]. The main steps are:
1. Establish the principles, basis and rules for valuation.
 2. Compile an Asset Inventory that provides the base data required for calculating asset values for each individual asset owned by an Authority. The assets should be appropriately classified and grouped if necessary.
 3. Produce initial values for the assets which involves:
 - a. Developing appropriate unit rates for the different asset classes.
 - b. Calculating the Gross Replacement Cost for each asset or group of assets.
 4. Calculate the consumption of the assets, which involves:
 - a. Calculating depreciation of assets.
 - b. Reviewing for and calculating impairment.
 5. Calculate Depreciated Replacement Cost.
 6. Prepare the Valuation Report.
- 4.7.7 The Depreciated Replacement Cost is calculated as:

<p>Depreciated Replacement Cost = Gross Replacement Cost – Accumulated Depreciation & Impairment</p>

4.8 COMMUTED SUMS

- 4.8.1 The ownership of a highway structure may change during its service life, for example when a privately developed road is adopted by a highway authority.

- 4.8.2 A commuted sum is a compensation that may be paid by the current owner of a structure to the new owner to cover the future liabilities and costs involved in the upkeep and replacement of the structure in perpetuity.
- 4.8.3 The new owner taking over responsibility for a structure or structures should decide whether he wishes to charge the commuted sum bearing in mind the additional financial burden this would impose, the willingness of the current owner, and the interests of the travelling public.
- 4.8.4 The commuted sum should normally include all costs that are likely to be incurred by the new owner, including:
1. Repairing any existing defects/damage at the time of transfer.
 2. Removal of substandard features to meet current national standards.
 3. Strengthening to meet the current assessment loading requirements – the share of costs should be based on the legal obligations of the current owner.
 4. Monitoring of a substandard structure, including the maintenance of any temporary restrictions and the associated signage.
 5. Future inspection, maintenance and renewal costs.
 6. Running or operating costs (e.g. energy costs).
 7. Insurance costs, if relevant.
 8. Reconstruction of the asset at the end of its service life, in full or in part, in a manner that is technically feasible and financially efficient. Several reconstructions may be considered for assets with short service lives.
- 4.8.5 The cost of works should include all costs that are likely to be incurred by the new owner such as: preliminaries and site preparation; the direct cost of plant, material and labour; design and supervision, traffic management, compensation payable to rail, canal or utility organisations for disruption to their services, etc.
- 4.8.6 All costs included in the commuted sum should be calculated at present day prices and considering the construction techniques, maintenance standards, and procurement methods generally adopted by the new owner in managing their stock of highway structures. All future costs should be discounted to their present value using the HM Treasury discount rate prevalent at the time of transfer or when the commuted sum is paid (currently 3.5%).
- 4.8.7 An 'Acceptance Inspection' of the structure should be performed by the new owner as described in Section 6 at the time of the transfer. Based on the findings of this inspection and examination of previous records and design/assessment calculations, the extent of works required to restore the structure to a reasonable state of repair and to meet current national standards and specifications should be established.
- 4.8.8 A 'whole life maintenance plan' should be developed using the principles and procedures given elsewhere in this Code to identify routine, preventative and other major maintenance and renewal work that may be needed during the remaining service life of the structure. Appropriate service lives should be

assumed for finite life components such as bearings, expansion joints, waterproofing, etc. based on judgement or past records. Appropriate cycle times for preventative maintenance (such as re-painting, silane treatment, re-pointing) and intervals for major maintenance (such as concrete repairs) should be estimated based on the characteristics of the structure, material of construction, age, environment and levels of traffic. Guidance on typical maintenance costs and cycle times is given in Appendix D of *Strengthening of Railtrack owned highway bridges* [6].

- 4.8.9 The remaining service life of a structure should be taken as 120 years by default. However, this should be adjusted where assessment or whole life cost analysis indicates a reduced economic remaining life taking account of future growth in traffic. In some cases a structure may need to be widened or replaced as part of a highway widening scheme. In such cases the obligations of the current owner in paying towards the cost of widening should be ascertained in calculating the commuted sum.
- 4.8.10 The reconstruction cost of the structure at the end of its service life should be evaluated using the guidance given in the *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2] for calculating the Gross Replacement Cost of the asset. In general the concept of 'modern equivalent asset' should be used unless the structure is a heritage or listed asset in which case an 'as-like-as-reasonably practicable' replacement should be used.

4.9 RECOMMENDATIONS

- 4.9.1 The recommendations for financial planning and resource accounting of highway structures are:
1. Financial plans should be prepared covering short, medium and longer term time horizons for the maintenance of highway structures. The plans should provide the basis for targeting investment in achieving the authority's Strategic Transport Plan, e.g. LTP or LIP.
 2. Appropriate policies and procedures should be implemented for the accounting of expenditure on structures in accordance with financial reporting standards, established accounting practices and guidance.
 3. Appropriate policies and procedures should be implemented for the asset valuation of highway structures for inclusion in the authority's Balance Sheet. The valuation should follow financial reporting requirements and guidance provided in *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2].
- 4.9.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Establish proper policies and procedures for the capitalisation of expenditure on structures maintenance, renewal and enhancement (Section 4.6).
TWO	<ul style="list-style-type: none"> • Prepare a Medium Term Financial Plan to support funding processes such as LTP, Spending Reviews, etc (Section 4.5). • Prepare Annual Financial Plan to provide a basis for setting the Annual Budget (Section 4.5). • Adopt the recommended procedures for determining commuted sums (Section 4.8).
THREE	<ul style="list-style-type: none"> • Prepare an integrated long term Transport Asset Management Plan, Medium Term Financial Plan and Annual Financial Plan as recommended. The plans should represent consequences of under-funding, by say 10%, 20% and 30% (Section 4.5). • Establish a regime for the asset valuation of highway structures in accordance with the CSS Guidance Document (Section 4.7).

4.10 REFERENCES FOR SECTION 4

1. *The Prudential Code for Capital Finance in Local Authorities*, CIPFA, 2003.
2. *Guidance Document for Highway Infrastructure Asset Valuation*, County Surveyors Society, 2005.
3. *Financial Reporting Standard 15 – Tangible Fixed Assets*, Accounting Standards Board, 1999.
4. *Code of Practice on Local Authority Accounting in the United Kingdom 2004 – A Statement of Recommended Practice (SORP)*, CIPFA/LASAAC, 2004.
5. *Resource Accounting Manual*, HM Treasury, www.resource-accounting.gov.uk
6. *Strengthening of Railtrack owned highway bridges*, County Surveyors Society and Railtrack, March 1999.

Section 5

Maintenance Planning and Management

This section covers the development and management of maintenance plans. The guidance describes procedures for developing maintenance plans that are cost effective and align with the authority's long term goals and objectives. In particular the guidance presents a formalised process for the identification of work, value management, value engineering, and for developing a forward work plan and work scheduling. Guidance is also provided on emergency response.

5.1 PURPOSE

- 5.1.1 Highway structures are exposed to a wide range of naturally-occurring and man-made factors that lead to, or directly cause, deterioration. In addition, the highway network is a dynamic system with changing user demands, some of which may be reflected in changes to codes and standards. The purpose of **maintenance** is to repair damage caused by deterioration, vehicle impact or vandalism, slow down or prevent the deterioration process and, where appropriate, meet the changing demands of users.



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- 5.1.2 The purpose of **maintenance planning and management** is to enable the bridge manager to develop and implement cost effective and sustainable maintenance plans for highway structures that support the safe operation of the network while delivering the required asset performance and Levels of Service. The maintenance planning and management process enables the bridge manager to deliver the authority's long term goals and objectives by developing maintenance plans that align with and provide detail to the work volumes and phasing identified in the Transport Asset Management Plan (TAMP). The process for developing the highway structures input to the TAMP is described in Section 3 (*Asset Management Planning*).

5.2 REQUIREMENTS

- 5.2.1 A maintenance planning and management process should be implemented that identifies needs, prioritises maintenance and produces cost effective and sustainable short to medium term work plans that are consistent with the long term Transport Asset Management Plan (TAMP). The process should cover the complete maintenance planning and management cycle.

- 5.2.2 A Forward Work Plan, which covers the next 1 to 3 year period, and an Annual Work Plan should be developed. These plans should be updated annually and should describe the work to be carried out and when it should be carried out.
- 5.2.3 The maintenance planning and management process should be linked to the TAMP in order to achieve the long term objectives and targets by delivering the work volumes and phasing identified in the TAMP.
- 5.2.4 An emergency plan should be developed and an associated emergency budget determined.

5.3 BASIS AND PRINCIPLES

- 5.3.1 Maintenance planning and management should be based on a formalised process that supports the bridge manager in the identification of needs and their development into robust and justifiable short to medium term maintenance plans. The maintenance planning and management process should include recognised good practice such as Value Management and Value Engineering.
- 5.3.2 Maintenance planning and management should seek to achieve benefits in scheme design through analysis of synergies with other highway works, if this is possible. The effective combination of both highway and structures work can lead to cost savings and reduce network disruption and whole life costs.
- 5.3.3 A robust planning process should produce short to medium term maintenance plans that are balanced, justifiable, achievable and sustainable over the longer term. These plans should deliver the work volumes and phasing identified in the TAMP. In this way the long term goals and objectives are delivered.
- 5.3.4 Lifecycle plans should be developed to support maintenance planning. Lifecycle plans describe the “optimal” maintenance intervention types and times for generic structure groups. Lifecycle plans support the short to medium term maintenance planning process described in this section and the long term asset management planning process described in Section 3 (*Asset Management Planning*).
- 5.3.5 Maintenance planning should adequately support the safe operation of highway structures. Performance levels should be identified at which a structure or component is considered to be sub-standard and which, if left unmanaged, may result in the structure becoming unsafe. Identifying minimum safety and performance levels assists the prioritisation of needs and development of maintenance plans.
- 5.3.6 Authorities should be suitably prepared for urgent safety and stability concerns and emergencies and deal with them effectively when they occur. An emergency response procedure should be developed for this purpose and an associated emergency budget determined.

5.4 OVERVIEW OF MAINTENANCE PLANNING

- 5.4.1 Maintenance planning is the process by which needs are identified, requirements analysed and maintenance plans prepared. All authorities should implement a formal maintenance planning process that is appropriate to the characteristics and size of their highway structures stock.

5.4.2 A logical maintenance planning process is shown in Figure 5.1. This may be taken as a template to describe the key components of a good maintenance planning process that aligns with the long term asset management planning process, shown in Section 3.6. The bridge manager should review the maintenance planning process presented in Figure 5.1 and identify how best to adopt it for their highway structures stock. The key components of the maintenance planning and management process are summarised below and described in more detail in the following sections:

1. **Inputs to the planning process** – the main sources of new information on structural condition and performance that inform the maintenance planning and management process (see Section 5.6).
2. **Emergency response** – a formal procedure for dealing with urgent safety and stability concerns and emergencies. This should include an Emergency Plan (see Section 5.7).
3. **Asset inventory, condition and performance data** – the data that supports maintenance planning and management, held in a format that allows it to be used effectively and efficiently (see Section 5.8).
4. **Determine current performance** – the available data is used to determine the current performance of highway structures in a manner that aligns with maintenance decision making (see Section 5.9).
5. **Identification of needs** – maintenance needs are identified from an understanding of current performance, target performance, lifecycle plans and on-going activities, e.g. inspections (see Section 5.10).
6. **Value Management** – a formalised approach to the prioritisation of the identified maintenance needs. Value Management should take into account criteria such as risk, functionality, benefits and impacts (see Section 5.11).
7. **Value Engineering** – a formalised process for identifying the optimal solution to a problem. The process should take into account option appraisal, scheme development, whole life costing and synergies with other highway schemes (see Section 5.12).
8. **Prepare Forward Work Plan** – Value Engineered schemes and non-value managed work are developed into a medium term work plan for the next 1 to 3 year period. The Forward Work Plan is aligned with the budget plan and any constraints, e.g. resources (see Section 5.13).
9. **Work scheduling** – a detailed schedule of work is prepared (Annual Work Plan) for the next financial year (see Section 5.14).
10. **Delivery of work** – develop remaining aspects of work/schemes (e.g. H&S plans, environmental management plans, etc.) and undertake work including on-site checks, where appropriate (see Section 5.15).
11. **Monitoring, review and feedback** – the Annual and Forward Work Plan should be regularly monitored and reviewed to assess work delivery. Changes should be made to the plans when necessary (see Section 5.16).
12. **Identify improvements** – the bridge manager should continually seek to improve the effectiveness of the maintenance planning and management process based on new information or lessons learned (see Section 5.17).

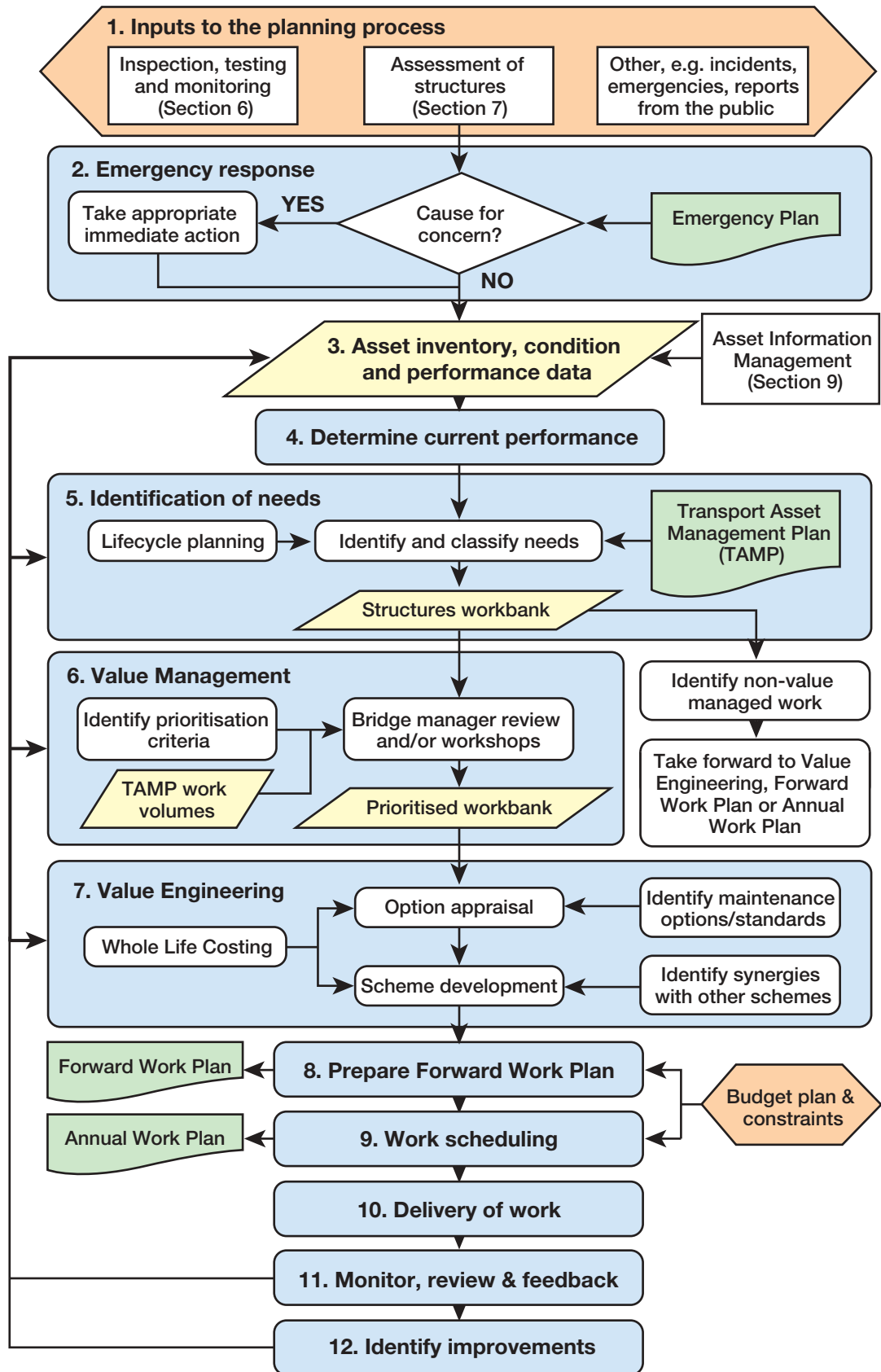


Figure 5.1: Maintenance planning and works delivery process

5.5 CLASSIFICATION OF WORK TYPES

5.5.1 An important feature of maintenance planning is the appropriate classification of all items of maintenance work. Classification provides a beneficial tool for analysing the workbank and removing appropriate work types from the Value Management and Value Engineering phases, i.e. regular and reactive maintenance. Eleven work type definitions grouped under three headings are given below that cover the majority of operational activities. These work types and the terminology should be used to provide clarity to work volumes identified in plans, i.e. TAMP, Forward Work Plan and Annual Work Plan.

1. Regular Maintenance

- a. **Inspections** – covers all inspection types, i.e. Safety, General, Principal and Special, see Section 6 (*Inspection, Testing and Monitoring*). Inspections include confined space inspections, boat inspections, underwater inspections and special follow-up investigations identified from the inspections.
- b. **Structural Reviews and Assessments** – structural reviews should ascertain the adequacy of structures to carry the specified loads when there are significant changes to usage, loading, condition or the assessment standards. A review should identify structures which need a structural assessment. An assessment quantifies the load bearing capacity of the structure in accordance with the appropriate current standards. Section 7 (*Assessment of Structures*) provides guidance on a regime for structural reviews and a procedure for structural assessments.
- c. **Routine Maintenance** – minor work carried out on a regular or cyclic basis that helps to maintain the condition and functionality of the structure and reduce the need for other, normally more expensive, maintenance works. Examples of routine maintenance common to highway structures include cleaning out expansion joints and drainage systems, greasing of metal bearings, removal of vegetation, removal of blockages in watercourses including removal of silt. Energy costs are also associated with routine maintenance.
- d. **Management of Substandard Structures** – normally constitutes implementing interim measures to protect users of substandard structures and may include monitoring. Guidance is given in *BA79 The Management of Sub-Standard Highway Structures* [1].

2. Programmed Maintenance

- a. **Preventative Maintenance** – work carried out to maintain the condition of the structure by protecting it from deterioration or slowing down the rate of deterioration. Preventative maintenance is justified on economic grounds because it provides minimum whole life cost maintenance. By timely intervention preventative maintenance reduces the need for essential work and/or the likelihood of essential work arising prematurely in the future. Examples of preventative maintenance include re-pointing, re-painting, minor defect repairs, silane impregnation, cathodic protection and re-waterproofing. Re-surfacing is not included because it is considered to be a road maintenance activity.

- b. **Component Renewal** – renewal of components that have a finite service life, e.g. bearings and expansion joints.
- c. **Upgrading** - work that brings an existing structure up to the appropriate current standard, e.g. strengthening, upgrading parapets, waterproofing. The work may have resulted from a change to standards or a change in requirements for the structure, e.g. enhanced network Levels of Service.
- d. **Widening and Headroom Improvements** – increasing the width or headroom of the existing structure. These improvements are generally considered to be network issues unless arising due to structural maintenance requirements.
- e. **Replacement** – a structure/component is replaced when it reaches the end of its useable life, excluding cyclic Component Renewal - item (2b) above. The replacement structure/component restores the full design performance of the structure/component it replaces (if the performance is enhanced it is classified as an upgrade – item (2c) above).

3. Reactive Maintenance

- a. **Emergency** – work that must be dealt with immediately due to the high risk the situation poses to public safety, e.g. caused by accidents such as bridge strikes.
- b. **Essential Maintenance** – major structural repair work and especially that undertaken when part or all of a structure is considered to be, or about to become, structurally inadequate or unsafe. Examples of essential maintenance include major concrete, masonry and steelwork repairs, and scour repairs.

5.6 INPUTS TO THE PLANNING PROCESS

5.6.1 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. Relevant condition and performance inputs to the maintenance planning and management process include, but are not restricted to:

- 1. **Inspection, testing and monitoring** – inspections, primarily General and Principal 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. Inspections are sometimes supplemented by testing and monitoring. Section 6 (*Inspection, Testing and Monitoring*) provides guidance on an appropriate inspection regime for highway structures and good practice for undertaking inspections, e.g. condition rating, inspection pro forma and data capture.
- 2. **Assessment of structures** – structural reviews identify structures that require a structural assessment, while structural assessments identify sub-standard structures. Resources are required for the structural reviews and assessments and for dealing with sub-standard structures. These should be taken into account in the planning process. Section 7

(*Assessment of Structures*) provides guidance on an appropriate regime for structural review and a process for structural assessment.

3. **Other** – may include incidents, emergencies and reports from the police or public, e.g. bridge strikes, scour damage from a flood, loose bricks.

5.6.2 The above data enables engineers to respond to any urgent needs or emergencies (see Section 5.7) and to plan work based on the actual current condition and performance. It also allows the maintenance planning process to provide the essential detail to the generic work volumes and phasing produced by the long term asset management planning process described in Section 3.7.

5.7 EMERGENCY RESPONSE

5.7.1 Paragraph 1.1.3 in Section 1 (*Introduction*) describes the obligation on authorities to provide a highway network that is *safe for use* and *fit for purpose*. To meet the former obligation all authorities should develop and implement a formal procedure for dealing with and responding to urgent safety and stability concerns and emergencies. These may include defects identified during a formal inspection, concerns reported by the public or damage as the result of events such as floods, vehicle impacts, vandalism, etc.

5.7.2 It is recommended that an Emergency Preparedness procedure for highway structures, such as that described below, is developed and maintained to deal with safety and stability concerns and emergencies as and when they arise. The Emergency Preparedness for highway structures should be derived from and consistent with the authority wide emergency planning regime.

5.7.3 The manufacturer's recommended spares should be held in stock for M&E equipment deemed to be safety critical, e.g. ventilation equipment in tunnels, lights in pedestrian underpasses (may be considered safety critical from a crime prevention perspective). This facilitates quick repair when an inspection identifies a defect.

Emergency Preparedness

5.7.4 Emergency preparedness is an essential part of network management and should be considered of equal importance to other maintenance works. A well considered emergency strategy is an essential part of operational safety requirements and risk mitigation. Without an emergency strategy problems may escalate to an un-manageable level, possibly leading to extended periods of network disruption.

5.7.5 Emergency preparedness is considered to have two distinct requirements:

1. The **emergency plan** that describes the method, contacts and mitigation measures used in dealing with an emergency.
2. Determining and allowing for the appropriate **emergency budget**.

Emergency Plan

5.7.6 As part of the preparation process, the authority should develop an emergency plan which provides details on how emergencies are to be addressed. It is normal for this to be part of a higher level emergency plan for highways, since

structures are only one component of the network. Suggested points for consideration are:

1. Policy and strategy - hazard analysis, mitigation, contingency and mobilisation.
2. Leadership - command structure during an incident.
3. Human Resource - staff responsibilities and staff requirements.
4. Resources - equipment used in an accident.
5. Processes - communication, emergency contacts and post-accident appraisal.

- 5.7.7 It may not be appropriate for all safety concerns/emergencies to follow the full procedure in the Emergency Plan. Authorities should develop the plan in a manner that enables a degree of flexibility. For example, loose bricks or spalling concrete can be quickly rectified by sending the contractor to site to make safe and repair. In this case the Emergency Plan should define a maximum response time for the contractor, which should also be recorded in a term maintenance contract, if applicable.
- 5.7.8 The plan should be reviewed on a regular basis to check that the information is current and all processes are still applicable. The emergency contact list should be circulated to all parties on the list.
- 5.7.9 In an emergency there should be defined lines of communication to enable the rapid dissemination of information. Incorrect details can lead to increased delay times and adversely affect response time and network safety. To aid the response process, only competent and appropriately trained people should be included in the contact list. Competent implies persons who have the ability and level of responsibility to make informed decisions regarding the integrity of a structure during and after an incident.
- 5.7.10 The Emergency Plan may define reaction times, e.g. the time taken to secure the site, or the time taken to install mitigation methods. Reaction times may be monitored to assess the effectiveness of the Emergency Plan and identify areas for improvement.

Emergency Budget

- 5.7.11 An estimate for emergency expenditure should be included within an appropriate budget, e.g. annual highway maintenance budget. The estimate for emergency expenditure should also be included in the TAMP.
- 5.7.12 When deciding on the annual and/or longer term budget allocation, costs should be based on experience or forecasted from past expenditure. Once identified a budget estimate should be automatically funded in the rolling programme of works. The allocation should be re-assessed at regular intervals to check that there are sufficient funds available to mitigate risk.

5.8 ASSET INVENTORY, CONDITION AND PERFORMANCE DATA

- 5.8.1 The asset inventory, condition and performance data should hold the information described in Section 9 (*Asset Information Management*). This

should provide up-to-date information that can be used to determine the current condition and performance of elements and structures.

- 5.8.2 The data should be held in a format that allows it to be easily entered, analysed and manipulated during the planning process, preferably in a computerised format. Data entry may be performed by administration staff or engineers. In the latter case data entry, especially for General Inspections, should be combined with the identification of needs (Section 5.10) in order to produce a more time and cost efficient approach. The highway structures stock should be divided into groups and sub-groups that have similar deterioration characteristics and maintenance needs (as described in Step 2 of Section 3.7 and in Section 9.6).
- 5.8.3 Any computerised system should be commensurate with the size and nature of the highway structures stock and the level of refinement used in the maintenance planning process. Section 10 (*Framework for a BMS*) describes generally the functionality required from a BMS to support the Good Management Practice recommended in this Code, including the maintenance planning process.

5.9 DETERMINE CURRENT PERFORMANCE

- 5.9.1 The asset inventory, condition and performance data (Section 5.8) should be used to determine the current performance of the highway structures in a way that supports the identification of needs (Section 5.10) and Value Management (Section 5.11). Much of the information should be in a format that can be readily used for identifying needs, for example element condition data and assessed capacity. Some data may require manipulation in order to provide information that assists identification and Value Management, for example, structure specific Performance Indicator values (see Section 3.8).
- 5.9.2 The current performance should be determined for individual elements and/or structures using absolute measures, e.g. severity and extent of a defect or assessed capacity of a structure, or using performance measures such as those described in Section 3.8 if appropriate. The description of current performance should be commensurate with the level of detail required for short term maintenance planning. This implies a greater reliance on absolute measures that describe current condition and performance in detail rather than performance measures. Performance measures are more suited to determining performance in the long term asset management planning process described in Section 3.7.

5.10 IDENTIFICATION OF NEEDS

- 5.10.1 The purpose of this task is to identify and document all maintenance needs on highway structures and the associated cost estimates. The documented maintenance needs and costs are referred to as the structures workbank. The structures workbank forms the basis of the subsequent Value Management and Value Engineering processes.
- 5.10.2 A formal approach to the identification of needs should be developed but the bridge manager should be aware that maintenance needs can arise due to a wide range of factors, some of which may not be covered by a formal approach. Common criteria that should inform the identification of needs are:

1. **Condition and performance data** – the data described in Sections 5.8 and 5.9 should be assessed by a suitably qualified and experienced engineer to identify needs.
2. **Lifecycle Plans** – a Lifecycle Plan describes the long term strategy for managing a group of similar structures with a view to minimising whole life costs while providing the required levels of performance. Lifecycle Plans are used to identify maintenance cycles and intervention thresholds.
3. **Transport Asset Management Plan** – identifies regular maintenance needs (e.g. inspections, structural reviews and assessments and routine maintenance) and improvement/development schemes planned for the TAMP period.

5.10.3 The following sections describe the above criteria in more detail. Some modern structures also have Maintenance Manuals as required by Appendix A of *BD 62 As Built, Operational and Maintenance Records for Highway Structures* [2]. These should also be used to inform the identification of needs.

Condition and performance data

- 5.10.4 The condition and performance data should be reviewed periodically by a suitably qualified and experienced engineer to identify maintenance needs. It is recommended that General Inspection pro forma are reviewed and signed off no longer than two months after the inspection, but preferably within one month. Thereby the signing off and identification of needs are combined. Some authorities may also wish to combine data entry with these tasks, see paragraph 5.8.2.
- 5.10.5 This exercise is heavily dependent on the engineer's knowledge of the elements/structures and the appropriate methods for dealing with the needs. As a minimum the engineer should have knowledge of a range of appropriate maintenance techniques (examples are provided in Appendix I) and in which circumstances the techniques should be applied.
- 5.10.6 The bridge manager may wish to define some generic rules/guidelines, which define when a particular maintenance method should be used. These rules/guidelines are normally defined in the lifecycle plans (see below), but may need to be defined separately for situations that the lifecycle plans do not cover, e.g. when elements deteriorate below the intervention thresholds defined in the lifecycle plans and may require alternative maintenance techniques.

Lifecycle Plans

- 5.10.7 A lifecycle plan describes the long term strategy for managing a group of similar structures with a view to minimising whole life costs (or maximising whole life value) while providing the required levels of performance and is used to identify maintenance cycles and intervention thresholds. Lifecycle plans provide an important link between long term asset management planning (Section 3.7) and short term maintenance planning, because they are a fundamental component of both.
- 5.10.8 Step 6 of the asset management planning process (Section 3.7) describes how generic lifecycle plans should be developed and used to inform the planning process. The same lifecycle plans should be used to identify needs on specific

structures and elements. The cyclic/intervention rules established in the lifecycle plans are compared against the current condition and performance of a structure/element and the specific characteristics of the structure are assessed to determine if the lifecycle plan activity is appropriate, i.e. the lifecycle plans should be used as general guidance when identifying specific maintenance needs.

- 5.10.9 Where appropriate, lifecycle plans should be amended through the maintenance planning process because the bridge engineer is undertaking a more detailed review of needs compared to asset management planning. Such amendments should then be passed back to asset management planning to improve long term work predictions.
- 5.10.10 Lifecycle plans differ depending on whether an authority adopts a strategy to enhance (*Enhancement*), maintain (*Steady State*) or decrease (*Managed Deterioration*) the condition and performance of highway structures (also see Step 6 of Section 3.7). These terms are defined as:
1. **Enhancement** – a strategy that enhances the condition or performance of the structures stock and includes upgrading.
 2. **Steady State** – a strategy that maintains the current condition and performance of the structures stock.
 3. **Managed Deterioration** – a strategy that aims to manage and control the deterioration of the highway structures so that condition may deteriorate but not fall below a predefined condition and/or performance level. This strategy is generally used if decommissioning or replacement is planned in the near future.
- 5.10.11 The approach taken by the authority should be clearly described in the TAMP and associated lifecycle plans documented. A lifecycle plan should be developed for each structure group/sub-group (see paragraph 5.8.2). Refinement of the groups and sub-groups may prove beneficial as it allows greater management planning control through more targeted lifecycle plans, but more knowledge of deterioration rates and mechanisms is required.
- 5.10.12 Lifecycle plans should be developed using whole life costing, if appropriate, in order to establish the most cost-effective approach (see Appendix J). Whole life costs should not be the sole consideration and other issues such as asset performance and network safety should also be considered where relevant (see paragraph 5.12.11). Figure 5.2 shows examples of generic lifecycle plans that may be developed for different structure types.

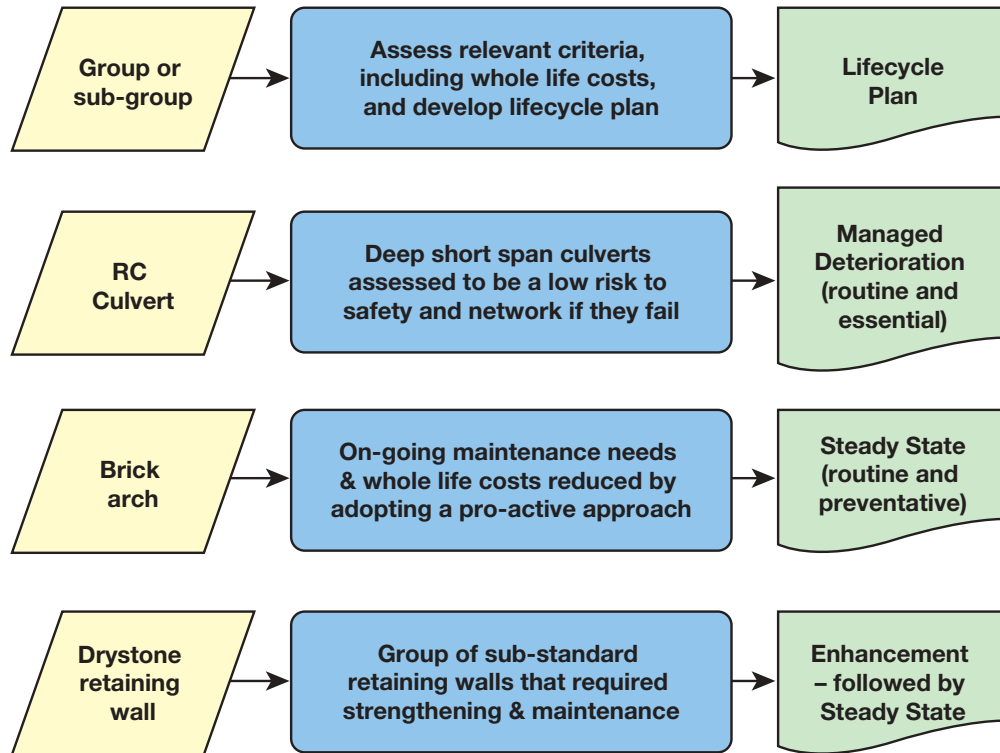


Figure 5.2: Examples of lifecycle plans

Transport Asset Management Plan (TAMP)

5.10.13 Regular maintenance, such as inspections, assessment and routine maintenance, is generally defined at a coarser level than the groups/sub-groups used for lifecycle planning. For example, one component of regular maintenance may be that all structures follow a two and six year General and Principal Inspection regime. Authorities may find this to be a more suitable approach for defining regular maintenance because it reduces the effort involved in identifying needs and reduces the complexity of lifecycle planning. Regular maintenance needs should be established in accordance with:

1. Inspections – Section 6 (*Inspections, Testing and Monitoring*).
2. Structural Assessments – Section 7 (*Assessment of Structures*).
3. Routine Maintenance – paragraphs 5.10.17 to 5.10.19 below.

5.10.14 Regular maintenance should be included in the structures workbank and be defined in the TAMP. It should be treated as non-value managed works, i.e. it does not go through the Value Management process. Instead, the work items are passed directly to Value Engineering (Section 5.12), work planning (Section 5.13) or work scheduling (Section 5.14), as appropriate.

5.10.15 The TAMP should identify other works that would not normally arise from a review of current performance or lifecycle planning. These works could include:

1. Network improvement schemes, e.g. bridge widening.

2. Works on highway structures that are linked to transport or urban development schemes e.g. to deliver requirements set out in the LTP or LIP.

5.10.16 The inclusion or exclusion of these schemes from the Value Management process (Section 5.11) depends on the funding stream. Irrespective of the funding stream, these works should go through the Value Engineering process (Section 5.12). Even when funded from a different source, these works should still be included in the workbank because it is the responsibility of the bridge manager to deliver them and, where possible, they should be programmed with other maintenance works to achieve cost savings.

Routine maintenance regime

5.10.17 The Highways Agency has a well developed routine maintenance regime which is described in *TRMM Volume 2; Routine and Winter Maintenance Code* [3]. This comprises tasks generally undertaken on a 12 monthly basis, such as removing graffiti, removing vegetation, clearing debris and bird droppings from components, clearing drainage systems, repairing gap sealant, cleaning sliding and roller surfaces of bearings and re-greasing, checking and, if necessary, tightening fixings on deck movement joints and removing debris and silt from culverts.

5.10.18 The Highways Agency considers that, whilst many of these tasks are fairly minor in themselves, failure to carry them out may lead to deterioration of the structure and the need for more costly repair operations in the future. The Highways Agency considers that generally a routine maintenance regime is cost effective in whole life terms.

5.10.19 Authorities are recommended to follow the guidance provided in *TRMM Volume 2* [3] and establish an appropriate routine maintenance regime for highway structures. In doing so particular consideration should be given to the following points:

1. Removal of graffiti – whilst the removal of all graffiti is commendable in improving the local environment, it can be an expensive operation if the graffiti is persistent. Some authorities have therefore decided only to remove racist or obscene graffiti (generally as soon as it is reported), unless there is little likelihood of more appearing in the medium term or there is an area-wide clean-up campaign organised by the local council or community body with the intention of keeping the area clean. Some urban authorities remove all graffiti in order to meet council objectives and tourist expectations; they accept this is a significant and essential expense.
2. Repair of gap sealant – sealant has often been specified by designers for gaps/joints where it is not essential and as a result some authorities have decided only to repair sealant where it is required. Examples include open joints that are visually unacceptable (but are not prone to vandalism) or where replacement will help prevent ingress of water which could lead to frost damage, corrosion of metalwork or reinforcement or unacceptable staining.

Structures Workbank

5.10.20 The structures workbank is a database of all work that is currently outstanding on the network, including estimated costs for doing the work. The workbank should include, and be categorised according to, the work types described in Section 5.5. It is recognised that certain work types by their very nature, e.g. re-active maintenance, cannot be planned in detail in advance but the workbank should still include a volume of work for these, albeit on unknown structures, based on past experience and engineering judgement. A workbank format should be established that is appropriate to local, and if appropriate, national needs. Figure 5.3 highlights three possible approaches.

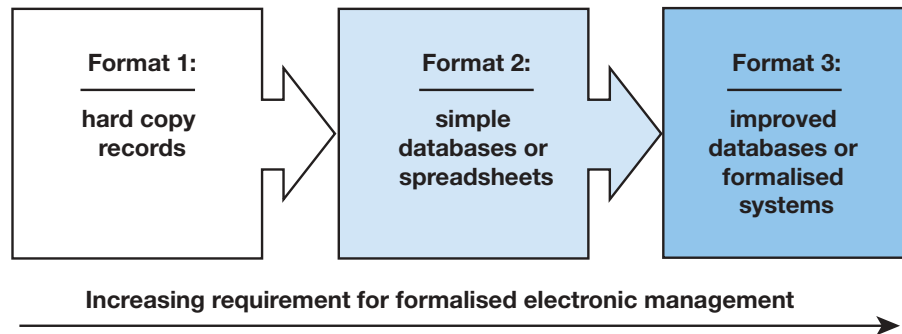


Figure 5.3: Possible formats for the structures workbank

5.10.21 As a minimum, it is recommended that a structures workbank database (Format 2) is developed. The benefits of a Format 3 approach should be considered for larger stocks of highway structures.

5.10.22 The workbank should include a full list of all maintenance required on the structures stock. The workbank should provide the following information for each item of work:

1. Name and number/reference of the structure.
2. Element where work is required.
3. Defect, including severity and extent (if appropriate).
4. Required work.
5. Work type (see Section 5.5).
6. Recommendation for when the work should be undertaken, i.e. which year.
7. Estimated cost.

5.10.23 The full list of information is taken forward to the Value Management and Value Engineering phases. Once work has been undertaken it should be identified as completed and removed from the workbank.

5.11 VALUE MANAGEMENT

5.11.1 Value Management is used to prioritise the identified needs compiled in the structures workbank. Figure 5.1 shows a process alongside Value

Management. This process is the planning (including value engineering if appropriate), scheduling and implementation of non-value managed work (see paragraph 5.10.13). The workbank identifies all work, not only value-managed work, and all the work needs to be appropriately managed.

- 5.11.2 Value Management should be used because it provides a formalised approach for assessing the benefits of undertaking maintenance and the associated risks of not undertaking maintenance. The risks and benefits should cover hard issues, e.g. condition and assessed capacity, that can be assessed objectively and soft issues such as local importance and synergies with other work that may need to be assessed subjectively.
- 5.11.3 The outcome of the Value Management process should be a prioritised list of actions in the structures workbank that is taken forward to the Value Engineering process, described in Section 5.12. It should also identify where there will need to be an option appraisal in the Value Engineering process (see paragraph 5.12.4).
- 5.11.4 Value Management should not be a complex and overly involved process. It should cover the appropriate criteria in a manner that enables engineers readily to compare and identify a priority score.
- 5.11.5 The full Value Management process is only appropriate for major schemes. A simplified process should be used to deal with common types of moderate and minor maintenance.

Value Management regime

- 5.11.6 A Value Management regime should be established that identifies the frequency of review and the approach to be taken. The regime should identify:
 1. **Value Management frequency** – some activities may be performed on a continuous basis, e.g. automated prioritisation of needs based on objective criteria. Other, more subjective criteria, e.g. local importance, are best analysed at regular intervals when one or more appropriate staff can review the latest needs. Value Management reviews or workshops held at least once every year, but preferably every six months, are likely to be appropriate for most authorities.
 2. **Prioritisation criteria** – the criteria considered during the Value Management process to prioritise needs. They may be objective or subjective in nature.
 3. **TAMP work volumes** – should be used to check broadly that appropriate volumes of work have been identified by the Value Management process.
 4. **Value Management review/workshops** – the staff to be involved in the Value Management review or workshop and the format this activity should take.
- 5.11.7 The Value Management regime should be appropriate to the size and characteristics of the highway structures stock.

Prioritisation Criteria

- 5.11.8 The Value Management process should be developed by suitably qualified and experienced staff who have a sound understanding of maintenance requirements and an awareness of longer term goals and objectives, as identified in the TAMP. The process should be transparent, encompassing the important prioritisation criteria, but it should also be flexible enough to assess a wide range of work and structure types. The sensitivity of the process to each prioritisation criterion should be fully trialled and the output assessed, possibly against predefined expectations.
- 5.11.9 The Value Management process should include a range of prioritisation criteria that are appropriate to the characteristics of the highway structures stock and network. As a minimum, prioritisation criteria should be considered that relate to the following three categories:
1. **Safety and functionality** – criteria in this category should seek to use information from the asset inventory and database to rank the importance of the need. Examples of criteria that could be considered are structure type, structure location, route carried, obstacle crossed, element condition, assessed capacity, height restriction and traffic flow restrictions. The criteria considered should influence the prioritisation score in an appropriate manner, e.g. as condition deteriorates the prioritisation score increases, as route classification increases the prioritisation score increases. The Condition, Availability and Reliability Performance Indicators described in Section 3.8 may be appropriate prioritisation criteria for this category.
 2. **Benefits and dis-benefits** – criteria in this category should seek to quantify in a simplified manner, the benefits and dis-benefits produced by addressing and not addressing a need. It may be more appropriate to use engineering judgement rather than an automated procedure. If the former approach is used it should be guided by a simple classification procedure, e.g. High, Medium or Low benefit/dis-benefit. Examples of benefits/dis-benefits that should be considered include lower or higher whole life costs, reduced or increased journey times, minimisation of network disruption, and integrating work items to achieve cost savings.
 3. **Socio-economic and environmental** – criteria in this category should cover the softer issues that cannot be readily quantified by an automated prioritisation process, e.g. local policies, user/customer perception, impact on local communities and businesses, environmental impact and sustainability considerations. A formalised approach should be developed that allows the reviewer, or workshop attendees, to quantify criteria easily, e.g. High, Medium or Low impact.
- 5.11.10 Many of the above criteria can be assessed through a formalised risk analysis and risk assessment approach. An overview of a risk approach is provided in paragraphs 5.11.13 to 5.11.17.
- 5.11.11 During the development of the Value Management process careful consideration should be given to the weighting of each criterion. While it is recognised that safety will be a motivating factor other issues should be addressed to ensure a balanced work programme, e.g. priorities of the TAMP. Otherwise the process may focus solely on more apparent maintenance needs

and fail to address preventative maintenance requirements. The system should also provide robust and justifiable prioritisation scores.

- 5.11.12 The level of refinement depends upon the complexity of the network and the number of issues that have to be accounted for (see Appendix K). The adopted system should allow for future development and have the ability to cope with increasingly complex situations.

Risk analysis and assessment

- 5.11.13 Risk analysis is the calculation of the magnitude of a risk, whereas assessment is a judgement on the acceptability of the risk. These are discussed below.

Risk analysis

- 5.11.14 The analysis of risk normally accounts for a large part of any prioritisation system. Risk analysis involves the calculation of the likelihood and consequence of an event, and is normally described as:

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

- 5.11.15 Likelihood is the possibility of an event happening, e.g. a failure or service reduction. Likelihood descriptions may vary between authorities, but should consider:

1. Current condition (severity and extent) and performance, e.g. assessed capacity and sub-standard elements.
2. Severity of environment, rate of deterioration and/or current age of the elements.
3. Changes in strategic policy, asset management planning or design and assessment standards that influence performance or service criteria.
4. Material type, mode of failure, extent of failure, etc.

- 5.11.16 Consequence is the associated effects of the event, e.g. increased journey times or a drop in customer perception of the service provided. The consequences associated with a failure or service reduction event may include:

1. **Safety** – the overall effects on the end user, including fatalities and injuries that would be caused by a failure.
2. **Functionality** – the impact of a loss or reduction in service. This may be considered at route, structure or component level.
3. **Cost** – increased/decreased costs due to bringing forward or delaying work.
4. **Sustainability** – whether the work meets the needs of the present without compromising the ability of future generations to meet their own needs.
5. **Environment** – environmental impacts, such as pollution caused through traffic delay, the sensitivity of the route/area, etc.

Risk assessment

- 5.11.17 The direct outcome of (Likelihood x Consequence) may require specialist interpretation. Therefore, a more straightforward approach is to assess the likelihood and consequence through a risk matrix (such as that shown in Table 6.1). To support a semi-automated approach to value management, a risk matrix should have values instead of the verbal descriptions shown in Table 6.1.

TAMP Work Volumes

- 5.11.18 The TAMP describes the work volumes and associated phasing needed to achieve the agreed long term goals, objectives and performance targets (see *Section 3: Asset Management Planning*). The work volumes provided in the TAMP are normally described in terms of quantities for work, where appropriate, and value of work. The work volumes identified by the Value Management process should align with the work volumes identified in the TAMP.
- 5.11.19 The Value Management review/workshop should be used to check that the Value Management process has produced sufficient volumes of work to align broadly with TAMP work volumes. If the work volumes do not align, the reviewer, or workshop attendees, should amend the prioritised list of work until the volumes align more closely with the TAMP work volumes. Alignment may require promotion and/or demotion of some work types, e.g. increase the proportion of essential maintenance to remove backlog.

Value Management review/workshop

- 5.11.20 The prioritisation criteria (paragraphs 5.11.8 to 5.11.12) and the TAMP work volumes (paragraphs 5.11.18 and 5.11.19) should be challenged in a formal Value Management review or workshop. In the context of this Code, a review is performed by one person, preferably the bridge manager, and a workshop is attended by more than one appropriately qualified and experienced person.
- 5.11.21 The review/workshop should assess each need in turn and give it a final prioritised score. The starting point for the review/workshop may be:
1. **Un-prioritised workbank** – in this case the review/workshop must address all the prioritisation criteria. It is advisable to use a small number of important criteria in order to avoid the review becoming overly complex.
 2. **Semi-prioritised workbank** – in this case an automated prioritisation would have already been performed based on the asset inventory and database information (primarily using the **safety and functionality** criteria). The review or workshop should therefore concentrate on the softer prioritisation issues that may not be appropriate for automation, e.g. **socio-economic and environmental**.
- 5.11.22 The cost estimates for the prioritised needs are compared against the 1 to 3 year funding plan (identified in the TAMP and/or the known short to medium term budget). Starting at the top of the prioritised list, i.e. taking the most critical need first, the cost estimates are added together until they equal the 1 to 3 year budget. The work volumes in this list need to be divided into the work type classifications (Section 5.5) to check they align with the work

volumes identified in the TAMP. If the work volume proportions are different from the TAMP the review/workshop should manipulate the prioritised list until they are the same or similar, e.g. promote or demote needs.

5.12 VALUE ENGINEERING

- 5.12.1 Value Engineering is the process of developing an optimal solution to a maintenance need and reducing waste and inefficient aspects of design, construction and maintenance [*Achieving Excellence in Construction*, 5]. Value Engineering takes the prioritised needs from the Value Management exercise and creates cost effective schemes that can be planned, scheduled and implemented.
- 5.12.2 The two key components of Value Engineering are **option appraisal** and **scheme development** (as shown in Figure 5.1). Important criteria that feed into these components include maintenance options and standards, Whole Life Costing and synergies with other schemes. Option appraisal, scheme development and Whole Life Costing are described below.
- 5.12.3 The full Value Engineering process is only appropriate for major schemes but a simplified process should be used to deal with moderate and minor works, where minor works should be grouped into those of a similar type to streamline the process.

Option Appraisal

- 5.12.4 Option appraisal is necessary to identify the appropriate maintenance solution when there is more than one practical alternative for addressing the maintenance need. There may be only one practical maintenance option for many of the identified needs and it may have already been determined from the Identification of Needs and Value Management exercises. When there is only one practical maintenance solution, option appraisal is not required and the work item can be passed through to the scheme development process.
- 5.12.5 The Value Management phase should have flagged up needs that are suitable for option appraisal. These needs should now be assessed by suitable personnel in order to identify the practical maintenance options. Appendix I provides information on some of the maintenance methods that may be considered. Personnel suitable for assessing options may include:
1. Bridge manager/engineer and other suitably qualified and experienced staff within the authority.
 2. External consultant and contractor staff with suitable experience and preferably a sound knowledge of the structures and network.
- 5.12.6 It is beneficial to involve the aforementioned personnel as early as possible in the exercise as this may lead to alternative proposals that benefit the network and lead to long-term savings. Early contractor involvement may enable the cost of work to be more robustly informed and effectively assessed. This process increases confidence levels and makes achievement of the planned work regime more likely.
- 5.12.7 The options should be analysed using Whole Life Costing (see Appendix J) to identify the most cost effective solution. Larger maintenance or improvement needs may merit the use of more sophisticated analysis techniques that

account for a wider range of socio-economic issues, e.g. Multi Criteria Decision analysis (see Appendix K). Expert advice should be sought regarding the suitability of applying more sophisticated techniques.

- 5.12.8 Large upgrade or improvement schemes may require a formal public consultation exercise. In such cases, authorities should identify appropriate parties to include in the consultation, e.g. local residents and businesses, and give them a suitable opportunity to comment on the options proposed.

Scheme Development

- 5.12.9 Scheme development is the effective combination of individual work items into schemes, in which each item makes best use of available funding and resources.
- 5.12.10 Procurement routes have a major effect on scheme development and out-turn costs. Senior managers, bridge managers and budget holders should be involved in the choice of procurement routes. In choosing a procurement route due consideration should be given to obtaining value for money, monitoring quality and rewarding or penalising good/poor quality respectively. The adoption of supply chain partners helps in the effective choice of maintenance solutions because advice can be sought at an earlier stage. Early contractor involvement is one method available.
- 5.12.11 The scheme development process should focus on the minimisation of network disruption and minimisation of whole life costs without compromising other important aspects such as appearance, access arrangements, environmental and sustainability issues, etc. It should be recognised that it may not be possible to minimise both network disruption and whole life costs and a compromise may have to be accepted. When developing schemes a number of alternative techniques are available for combining work items, each having different outcomes. Commonly used techniques include:
1. **Combine different work items on one structure** - addresses all actions on one structure thereby creating one period of longer network disruption compared to several interventions of shorter individual disruption but possibly longer total disruption. This technique may have relatively high scheme costs because the contractor has to mobilise for a range of activities and possibly more than one contractor is required.
 2. **Combine similar work types** – a scheme of works that concentrate on one specific work type or similar work types. This technique should achieve cost savings by procuring the work in bulk because mobilisation fees are reduced and the contractor is provided with a steady work stream. A disadvantage is increased network disruptions at a particular location because different contractors may visit one structure in order to carry out their specific activities.
 3. **Combine schemes based on route or area** – this technique is similar to technique 1 above except that it is extended to cover a series of schemes on a route. It should achieve cost savings by procuring the work in bulk because contractor mobilisation fees are reduced and they are provided with a steady work stream. A disadvantage is that a number of contractors are likely to be required, leading to the possibility of programme extensions, site conflicts and continued network disruption over a short period.

5.12.12 The developed schemes are used to prepare the Forward Work Plan.

Whole Life Costing

5.12.13 The traditional method of option appraisal in the construction industry focused solely on the capital works cost and neglected the long-term requirements and cost. Therefore, a cost-effective solution was considered to be one with a low construction cost. This approach resulted in many cases in the development of short-term solutions that proved expensive in the longer term due to durability and maintenance problems. Whole Life Costing (WLC) is used to assess the financial merits of a scheme over the long term, thus preventing short-term expenditure from skewing decisions.

5.12.14 WLC should be used to assess maintenance needs that have more than one solution, i.e. option appraisal, and to determine the most cost effective schemes. Details of WLC are provided in Appendix J.

5.13 PREPARE FORWARD WORK PLAN

5.13.1 The Forward Work Plan is a detailed 1 to 3 year programme of work. This provides details of the schemes to be carried out in the 1 to 3 year period and their approximate annual phasing.



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5.13.2 The Forward Work Plan should draw together all the work that has passed through the Value Management and Value Engineering phases, i.e. developed schemes, and non-value managed work, e.g. inspections, structural assessments, routine maintenance and management of substandard structures.

5.13.3 The preparation of the Forward Work Plan should also provide a final check against the funding levels and work volumes/phasing identified in the TAMP. It is important that the Forward Work Plan delivers the TAMP work volumes in order to achieve the agreed long-term goals and objectives.

5.14 WORK SCHEDULING

5.14.1 Work scheduling and management practices are used to develop effective programmes and should highlight all the in-year maintenance activities to be undertaken. The activities should be documented in the Annual Work Plan. During the development process consideration should be given to achieving a balanced programme, minimising network congestion (see paragraph 2.13.2) and producing detailed works costs.

- 5.14.2 The work schedule (Annual Work Plan) should contain dates (preferably start and finish and any significant interim milestones) for all works undertaken during a given year. The schedule should include a balanced mix of work, as outlined by the Forward Work Plan and the TAMP.
- 5.14.3 The schedule should assess the likely effects on the network and the disruption caused to the end-user. To help in reducing disruption, where possible, schemes should be combined with other network maintenance, e.g. it may be beneficial for painting, silane and waterproofing to be replaced during road renewal schemes. Many of these synergies should already have been identified by the Value Engineering phase described in Section 5.12.
- 5.14.4 LoBEG has developed a prioritisation system, to be used by all 33 London Boroughs, for the scheduling of bridge strengthening schemes (see Appendix K). The development of the LoBEG prioritisation system included full consultation and agreement with all 33 Boroughs.

5.15 DELIVERY OF WORK

- 5.15.1 Work delivery includes the development of the remaining aspects of works/schemes (e.g. H&S plans, environmental management plans, etc.) and undertaking the work, including on-site checks, where appropriate. Section 2 (*Management Context*) provides guidance on the overall management context and environment in which works/schemes have to be delivered.
- 5.15.2 Work delivery should recognise the need for data. This may include monitoring different aspects of work delivery to feedback and inform the maintenance planning process (see Section 5.16).

5.16 MONITORING, REVIEW AND FEEDBACK

- 5.16.1 The Annual and Forward Work Plan should be regularly monitored and reviewed to assess work delivery, i.e. planned programme and costs vs actual. Changes may be required to the planned schedule of works if it has deviated significantly from the original plan. Feedback loops should also be implemented to assess and record out-turn costs and the quality of the final solution (this data may also inform improvements, see Section 5.17 below).
- 5.16.2 The workbank should be continually reviewed to check that maintenance needs are being properly addressed and removed from the workbank once acted upon. It is helpful to record the dates when the scheme is included and removed from the workbank so the turn around can be monitored.

5.17 IDENTIFY IMPROVEMENTS

- 5.17.1 The bridge manager should continually seek to improve the efficiency and effectiveness of the maintenance planning and management process. Improvements to the maintenance planning and management process may align with improvements to the long term asset management planning process (see paragraph 3.7.69), and the bridge manager should seek to combine the work required on these improvements where appropriate.
- 5.17.2 Feedback from inspections and maintenance work should be used to improve the accuracy and development of lifecycle plans and maintenance strategies. Out-turn costs should be used to improve workbank cost estimates, whole life costing and asset management planning.

5.18 RECOMMENDATIONS

5.18.1 It is recommended that a formalised maintenance planning and management process should be implemented that identifies needs, prioritises maintenance and produces cost effective and sustainable short to medium term work plans that are consistent with the long term Transport Asset Management Plan. The processes should cover the complete maintenance planning and management cycle.

5.18.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Check that the inputs to the maintenance planning and management process are in place (Section 5.6). • Implement a formal emergency response process (Section 5.7). • Implement a formal process for identification of needs (Section 5.10). • Develop and implement an annual work plan that covers re-active maintenance (Section 5.14). • Identify how maintenance work should be classified (Section 5.5).
TWO	<ul style="list-style-type: none"> • Store the data required for maintenance planning and management in a suitable format (Section 5.8) and determine current performance (Section 5.9). • Develop and implement a regular maintenance regime (Section 5.10). • Develop and implement lifecycle plans for common forms of bridge construction (Section 5.10). • Develop and implement Value Management (Section 5.11). • Develop and implement an Annual Work Plan that covers regular, programmed and re-active maintenance (Section 5.14). • Implement a feedback loop to monitor and review delivery of the Annual Work Plan (Section 5.16). • Identify and implement improvements to the maintenance planning and management process (Section 5.17).
THREE	<ul style="list-style-type: none"> • Develop and implement lifecycle plans for all groups and sub-groups of highway structures (Section 5.10). • Develop and implement Value Engineering (Section 5.12). • Develop and implement a Forward Work Plan for the next 1 to 3 years (Section 5.13) and monitor delivery (Section 5.16). • Organise the different components of the maintenance planning and management process into a complete and integrated process (Section 5.4) and align with the long term asset management planning process (Section 3.7).

5.19 REFERENCES FOR SECTION 5

1. *BA79 The Management of Sub-Standard Highway Structures*, DMRB 3.4.18, TSO.
2. *BD 62 As Built, Operational and Maintenance Records for Highway Structures*, DMRB 3.2.1, TSO.
3. *TRMM Volume 2; Routine and Winter Maintenance Code*, TSO.
4. *Framework for Highway Asset Management*, County Surveyors Society, April 2004.
5. *Achieving Excellence in Construction - Procurement Guide 04 - Risk and Value Management*, Office of Government Commerce (www.ogc.gov.uk).

Section 6

Inspection, Testing and Monitoring

This section provides guidance on the inspection, testing and monitoring regimes and techniques required to provide information for and to support good structures management. Overall requirements and principles are set down to provide a basis for establishing appropriate regimes of inspection, testing and monitoring for different types of structure. Guidance is also included on associated processes and procedures including condition recording, non-destructive testing techniques, structural integrity monitoring and reporting.

6.1 PURPOSE

- 6.1.1 The overall purpose of inspection, testing and monitoring is to check that the highway structures stock is *safe for use* and *fit for purpose* and to provide the data required to support the Good Management Practice identified in this Code, e.g. *Asset Management Planning* (Section 3) and *Maintenance Planning and Management* (Section 5).



- 6.1.2 Inspection, testing and monitoring form the basis of Good Management Practice and should be used to:
1. Provide data on the current condition, performance and environment of a structure, e.g. severity and extent of defects, material strength and loading. The data enables the bridge manager to assess if a highway structure is currently *safe for use* and *fit for purpose*, and provides sufficient data for actions to be planned where structures do not meet these requirements.
 2. Inform analyses, assessments and processes, e.g. change in condition, cause of deterioration, rate of deterioration, maintenance requirements, effectiveness of maintenance and structural capacity. The outputs inform management planning and enable cost effective plans, which deliver the agreed Levels of Service, to be developed.
 3. Compile, verify and maintain inventory data, e.g. structure type, dimensions and location, for all the highway structures the authority is responsible for. Section 9 (*Asset Information Management*) describes the data that should be held in the highway structures inventory.

- 6.1.3 The above points illustrate that the data provided by inspection, testing and monitoring is fundamental to highway structures management and hence to Good Management Practice. It is essential that authorities recognise the importance of inspection, testing and monitoring and seek to plan, perform, resource, and use them accordingly.

6.2 REQUIREMENTS

- 6.2.1 An adequate inspection regime should be implemented for all highway structures to check they are *safe for use* and *fit for purpose*. The inspection regime should be supplemented by testing and monitoring where appropriate.
- 6.2.2 The inspection regime should include Acceptance, Routine Surveillance, General, Principal, Special and Safety Inspections as required.
- 6.2.3 The inspection, testing and monitoring regime should provide data that aligns with and supports the Good Management Practice identified in this Code.
- 6.2.4 A procedure should be implemented whereby the inspector has a clearly defined duty to inform the bridge manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety.

6.3 BASIS AND PRINCIPLES

- 6.3.1 An inspection, testing and monitoring regime should minimise risks to public safety, provide sufficient data for management and make effective use of resources. The mix of techniques used in the regime, and frequencies at which they are applied, should be determined by considering appropriate criteria in an objective manner, e.g. through a formal risk assessment. The criteria should include, but not be restricted to, public safety, the characteristics of the assets, the consequence of failure, the environment the assets operate in, the services provided, typical rates of deterioration and susceptibility to damage.
- 6.3.2 The inspection, testing and monitoring techniques should be sufficient to:
1. Identify condition, defects and signs of deterioration that are significant to highway structure safety and management.
 2. Identify any significant changes in condition, loading or environment that have occurred since the last observation.
 3. Assess or provide information for the assessment of stability and serviceability.
 4. Determine or assist the determination of the cause, extent and rate of deterioration.
 5. Provide information that can be used to support highway structures management, i.e. the identification of needs and associated maintenance works.
- 6.3.3 The inspection, testing and monitoring regime should seek to meet the criteria described in paragraphs 6.1.1 to 6.1.3 in the most cost effective manner.

6.4 INSPECTION REGIME

- 6.4.1 The inspection regime should enable any defects which may cause an unacceptable safety or serviceability risk or a serious maintenance requirement to be detected in good time in order to safeguard the public and the structure and implement remedial actions. The regime should consist of a combination of Acceptance, Routine Surveillance, General and Principal Inspections of the whole structure and more detailed Safety and Special Inspections (including Inspections for Assessment), as necessary, concentrating on known or suspected areas of deterioration or inadequacy. The different types of inspection are described below and are followed by guidance on the inspection requirements of other owners, the frequency of inspections, scheduling of inspections and the inspection of Mechanical and Electrical (M&E) equipment.
- 6.4.2 All inspections should result in a report, in a format commensurate with the inspection type, which gives a clear and accurate description of the structure's condition. Inspection reporting is discussed in Section 6.5.

Routine Surveillance

- 6.4.3 All structures should be subjected to Routine Surveillance as part of regular Highway Safety Inspections carried out by highway maintenance staff. Routine Surveillance is normally undertaken from a slow moving vehicle. Inspectors should immediately report to the bridge manager any obvious defects that are apparent from the vehicle which need urgent attention, such as damage to the superstructure and bridge supports of overbridges, damage to parapets, flood damage, insecure expansion joint plates, etc. The bridge manager should be satisfied that the frequency of Highway Safety Inspections is suitable for the Routine Surveillance of highway structures and, if unsuitable, decide how to deal with the need for additional surveillance.
- 6.4.4 All highway structure management and maintenance staff should be encouraged to be vigilant at all times when moving around the network and to report anything that might need urgent attention. The general public should also be informed of the need to report any highway structure defects they feel may pose a risk to public safety. This is normally best achieved by providing appropriate contact details (e-mail and/or telephone) on the authority's website.
- 6.4.5 It is recommended that the bridge manager makes formal contact with the highway maintenance staff and, if necessary, explains the important features to observe or defects to report on highway structures during Routine Surveillance and the information that should be recorded if a defect is observed, e.g. structure location and defect description. The bridge manager's contact details, or the contact details of an appropriate member of their team, should be provided to the highway maintenance staff.

General Inspection

- 6.4.6 It is recommended that all highway structures should be subject to a regular General Inspection not more than two years following the previous General or Principal Inspection.
- 6.4.7 General Inspections comprise a visual inspection of all parts of the structure and, where relevant to the behaviour or stability of the structure, adjacent earthworks or waterways that can be inspected without the need for special access or traffic management arrangements. 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. Guidance on General Inspections for highway structures is include in *CSS Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting* [1] and *Addendum to CSS Bridge Condition Indicator Volume 2* [2].

Principal Inspection

- 6.4.8 It is recommended that all highway structures should be subject to a regular Principal Inspection not more than six years following the previous Principal Inspection unless a risk assessment, in accordance with paragraphs 6.4.27 to 6.4.34, has been carried out to define an alternative interval.
- 6.4.9 Principal Inspections comprise a close examination, within touching distance, of all accessible parts of a structure, including, where relevant, underwater parts and adjacent earthworks and waterways, utilising suitable access and/or traffic management works as necessary. Closed circuit television may be used for areas of difficult or dangerous access, e.g. obscured parts of a structure, confined spaces and underwater inspections.
- 6.4.10 A Principal Inspection may include a modest programme of tests, e.g. hammer tapping to detect loose concrete cover or half-cell and chloride measurements to enable risk of reinforcement corrosion to be assessed, when considered necessary.
- 6.4.11 A Principal Inspection should be of sufficient scope and quality to determine:
1. The condition of all parts of the structure.
 2. The extent of any significant change or deterioration since the last Principal Inspection.
 3. Any information relevant to the stability of the structure.
- 6.4.12 A Principal Inspection should establish:
1. The scope and urgency of any remedial or other actions required before the next inspection.
 2. The need for a Special Inspection and/or additional investigations.
 3. The accuracy of the main information on the structure held in the inventory.

Special Inspection

- 6.4.13 There are occasions when a more specific inspection, concentrating on the condition of particular parts of the structure, is required. This is known as a Special Inspection. The need for a Special Inspection normally arises due to specific circumstances or following certain events, for example:
1. When a particular problem is detected during an earlier inspection of the structure or of similar structures.

2. On particular structural forms or types, e.g. cast iron structures, post tensioned structures, structures strengthened with bonded plates.
 3. On structures that have loading or other forms of restrictions on use, e.g., restriction of traffic on bridges.
 4. When the necessary frequency or access arrangements for a particular part of the structure are beyond those available for General or Principal Inspections.
 5. On bridges that have to carry an abnormally heavy load - inspections may be done before, during and after the passage of the load.
 6. Following a bridge strike.
 7. Following a flood or high river flow to check for scour or other damage.
 8. To check specific concerns, possibly based on new information, e.g. concerns over the quality of previously used batches of rebar or concrete.
 9. Where a post tensioned bridge has a regime of Special Inspections implemented as a result of an earlier investigation or a Special Inspection is required in accordance with *BA 50 Post-tensioned Concrete Bridges, Planning, organisation and methods for carrying out Special Inspections* [3].
- 6.4.14 A policy should be developed clarifying when it is appropriate to carry out a Special Inspection. Further guidance on Special Inspections is provided in *BA 63 Inspection of Highway Structures* [4] and *BD 63 Inspection of Highway Structures* [5].

Inspection for Assessment

- 6.4.15 This is another type of inspection, which is carried out before a structural assessment. *BD 21* [6] provides guidance on undertaking an Inspection for Assessment and Section 7 (*Assessment of Structures*) deals with the need for the inspection.

Safety Inspection

- 6.4.16 A Safety Inspection may be undertaken following Routine Surveillance or after information has been received which indicates the structure is damaged and may be unsafe. The Safety Inspection should determine the extent of the damage and whether immediate safety precautions or other action should be taken. A Special Inspection may then follow to monitor the condition and effectiveness of interim measures and to determine what repair or other actions should be undertaken in the longer-term.

Acceptance Inspection

- 6.4.17 The need for an Acceptance Inspection should be considered when there is a changeover of responsibility for the operation, maintenance and safety of a structure from one party to another. 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. The Acceptance Inspection should include:

1. The identification of any permanent access provisions and features affecting the safety and security of the structure. These should be discussed in detail and agreement reached before handover.
2. The identification and handover of all the necessary records, maintenance and operating manuals which have an impact on the future management of the structure.
3. Agreement of the date on which the authority takes over responsibility for the structure. The agreement should be recorded in the Structure File.

6.4.18 It is recommended that Acceptance Inspections on new, existing and concession structures should also include the following as appropriate.

Handover of a New Structure

6.4.19 An Acceptance Inspection should be undertaken for new structures about one month before the issue of the completion documentation or opening to traffic. A Principal Inspection should be used for this purpose. The inspection should identify and record any defects, developing problems and work outstanding under the contract and secure agreement on any works to be completed before handover. This should act as the benchmark for the inspection carried out at the end of the Defects Correction Period and for subsequent inspections.

6.4.20 A construction contract normally includes a Defects Correction Period (also referred to as the Period of Maintenance or Defects Liability Period) during which the contractor is responsible for making good defects that appear. The period usually commences upon practical completion of the works and runs for a specified time frame, typically 12 to 24 months. The length of the Defects Correction Period should be specified in the contract.

6.4.21 An inspection should be undertaken prior to the end of the Defects Correction Period to identify all defects before the expiry of the contractual obligations. The timing of the inspection should be sufficient to allow agreement of the work to be undertaken by the contractor and, if necessary, enforcement of contractual obligations. The inspection may be a General or Principal Inspection depending upon the type and form of the structure and the length of time since handover or the last inspection.

6.4.22 Authorities may also wish to use the above, or a similar, procedure for accepting major maintenance work.

Transfer of an Existing Structure

6.4.23 An Acceptance Inspection should be undertaken prior to an authority taking over responsibility of an existing structure. A Principal Inspection should be carried out as part of the Acceptance Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient.

Handback after a Concession Period

- 6.4.24 An Acceptance Inspection should be undertaken before handback at the end of a concession period, e.g. a PFI or PPP type contract. The inspection should compare the current condition and performance of the structure against the measures specified in the contract. This should include a Principal Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient. This information should be used to identify and agree items of outstanding work to be completed, in order to satisfy the contract measures, before handback. The timing of the Acceptance Inspection should be sufficient to allow agreement of the outstanding work to be undertaken by the contractor and, if necessary, enforcement of contractual obligations

Inspection Requirements of Other Owners

- 6.4.25 Where other owners have structures within the footprint of the highway, they are responsible for ensuring the safety, integrity and adequacy of those structures for use by the public. The inspection of other owner structures normally falls into two categories:
1. **Newer structures** – an appropriate inspection regime is likely to have been recorded in the licence/maintenance agreement.
 2. **Older Structures** – there is unlikely to be a statement of inspection requirements in a formal agreement. The highway authority only has the power to act to ensure safety in default of action by the other owner when the structure becomes dangerous. A highway authority cannot insist retrospectively on a regime of inspection and maintenance to be undertaken by the other owner where there is no clear statement of requirements in a formal agreement.
- 6.4.26 In certain cases a highway authority can be reasonably confident on the basis of available information that an owner is acting responsibly and has an adequate regime of inspections in place, e.g. Network Rail, BRB (Residuary), British Waterways, London Underground Limited. In some cases, however, this conclusion cannot be justified and the highway authority should carry out General Inspections of such structures in the wider interests of public safety. This in no way negates the primary responsibility of the actual owner toward public safety and structural integrity.

Frequency of Inspections

- 6.4.27 Paragraph 6.4.6 recommends a General Inspection be undertaken not more than two years after the previous General or Principal Inspection and paragraph 6.4.8 recommends a Principal Inspection not more than six years after the previous Principal Inspection. These inspection frequencies are generally interpreted as a two and six year General and Principal Inspection regime. This regime is suitable for most highway structures but in some circumstances it may be necessary to decrease the intervals while in others it may be acceptable to increase the intervals.

Decreasing the Inspection Interval

- 6.4.28 When a structure is known or suspected to be subject to a rapid change in condition or circumstances, e.g. structures subject to ASR or chloride induced corrosion, the default interval between inspections should be reduced

accordingly. The reduced interval should be such that any significant change in condition or circumstances can be identified and assessed in time for appropriate action to be implemented. The revised inspection regime and reasons for more frequent inspections should be recorded in the Structure File. The more frequent inspection may be limited to a specific element or feature.

Increasing the Inspection Interval

6.4.29 Highway structures are long life assets and their constituent components deteriorate at different rates due to a wide range of factors, e.g. material type, construction form, usage, exposure and maintenance. The recommended two year General Inspection and six year Principal Inspection regime may not always represent the most cost effective solution for some structures while in some cases it may not be feasible to follow these intervals due to access difficulties, e.g. tenanted arches. Inspection intervals may be increased for these structures. The suitability of increased inspection intervals should be assessed and justified using a risk assessment, giving due consideration to the following:

1. A General Inspection at not more than two years after the previous General or Principal Inspection is recommended good practice for all highway structures. Relaxing the General Inspection intervals supported by risk assessment should only be considered as an interim solution as authorities work towards a two year interval.
2. The interval between General Inspections should not exceed three years, i.e. a General Inspection should occur at the latest three years after the previous General or Principal Inspection.
3. Type, quality, extent and results of previous inspections, testing, monitoring, structural assessment, etc.
4. Accessibility of all parts of a structure, for example:
 - a. If the inspector can get close to all parts of a structure during a General Inspection, there may be little difference between the General and Principal Inspection. A Principal (or Special) Inspection may only be required when the need has been identified by a General Inspection.
 - b. If the inspector cannot get close to all parts of the structure during a General Inspection and there is a likelihood of significant defects not being detected, there is a need for regular Principal (or Special) inspections.
5. Providing suitably current data for calculating the Condition Performance Indicator (Bridge Condition Indicator).
6. The ease of producing practical and workable inspection budgets and schedules, i.e. scheduling may become unduly complicated if different inspection intervals (especially for General Inspections) are used across the highway structures stock.

Risk Assessment

- 6.4.30 A risk assessment should be specific to a structure or group of similar structures. An assessment method should be developed that seeks to quantify:
1. The likelihood of rapid deterioration or other incidents.
 2. The consequence of unchecked deterioration/incidents.
- 6.4.31 Assessment of the likelihood of rapid deterioration or other incidents should include, but not be limited to, the following criteria where relevant:
1. Exposure severity, e.g. mild, moderate or severe, and external influences which may cause rapid deterioration or failure, e.g. significant change in use (above, adjacent or beneath), loading that exceeds existing restrictions, stray current/electrical corrosion.
 2. Current condition and level of contamination, e.g. chlorides or carbonation, and how these conditions may influence the rate of deterioration. The age of the structure may also be considered.
 3. Material type and the typical rate of deterioration for the observed deterioration mechanism. Many defects are known to take many years to develop to the point where they require maintenance or present a risk to structural integrity or public safety. The maintenance/repair history of the structure should be taken into consideration and structure specific characteristics such as fatigue-prone details and susceptibility to scour damage, should be considered.
 4. Severity and extent of damage due to incidents, such as vehicle impact, scour and vandalism, and whether this is likely to lead to further deterioration before it is repaired.
 5. Potential mode of failure, e.g. brittle or ductile failure.
 6. Extent of failure, e.g. local or global failure.
- 6.4.32 Assessment of the consequence of unchecked deterioration and other incidents should include, but not be limited to, the following criteria where relevant:
1. Consequence of failure of the structure or its elements, e.g.
 - a. The likely number of fatalities and casualties based on the size of the structure and traffic volume on the route crossed and obstacle crossed.
 - b. Traffic delay costs incurred through diversions/congestion based on the route type and availability of diversion routes.
 - c. Socio-economic impact based on the location of the structure and the community served, e.g. industrial, business or residential.
 2. Increased costs due to unchecked deterioration/incidents resulting in more expensive maintenance work at a later date.

6.4.33 The suitability of increased inspection intervals should then be assessed through a risk matrix, e.g. as shown in Table 6.1.

Table 6.1 Example of a Risk Assessment Matrix

		Consequence of unchecked deterioration/incident		
		Low	Medium	High
Likelihood of rapid deterioration or other incidents	Low	Suitable for increased interval	Suitable for increased interval	May be suitable for increased interval
	Medium	Suitable for increased interval	May be suitable for increased interval	Use recommended inspection regime
	High	May be suitable for increased interval	Use recommended inspection regime	Use recommended inspection regime

6.4.34 The risk assessment should be recorded in the Structure File and agreed by the bridge manager before the frequency of inspections is changed. The validity of the risk assessment should be re-confirmed and recorded by the bridge manager after each Principal Inspection or when any other significant change in the condition of the structure becomes apparent.

Scheduling Inspections

6.4.35 Inspection scheduling should seek to make the most efficient use of the resources available and minimise disturbance to the public, e.g. plan inspections to take advantage of traffic management planned for other reasons.

6.4.36 Inspections should ideally be scheduled in accordance with the frequencies described in paragraphs 6.4.1 to 6.4.34, although a rational schedule that takes account of the stock characteristics should be developed. It might be appropriate, for example, to undertake inspections along particular routes or in the same area within the programme year. In such circumstances the opportunity should be taken to move nearer to the preferred frequencies, e.g. by bringing forward inspections.

Inspection of Mechanical and Electrical Equipment

6.4.37 Mechanical and Electrical (M&E) equipment associated with highway structures includes, but is not limited to, lighting and ventilation in road tunnels, lighting in pedestrian underpasses and hydraulic rams on moveable bridges. The stewardship of this equipment is likely to be the responsibility of the bridge manager.

6.4.38 An appropriate regime of inspection (and testing) of M&E equipment should be established. The inspection regime should be commensurate with the principles defined in Section 6.3 and the manufacturer’s recommendations.

6.4.39 The manufacturer’s recommended spares should be held in stock for M&E equipment to facilitate quick repair when an inspection identifies a defect. This should be accounted for in the *Identification of Needs* process in Section 5.6.

- 6.4.40 Useful guidance on the inspection and testing of M&E equipment associated with highway structures is provided in *Series 7000 Mechanical and Electrical Installations in Road Tunnels, Moveable Bridges and Bridge Access Gantries MCDHW* [7].

6.5 INSPECTION PROCESS

- 6.5.1 This section describes the inspection process including preparation, undertaking inspections, recording, reporting and evaluation of observations and measurements.



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- 6.5.2 Inspections should be carried out by appropriately qualified, trained and experienced personnel (Section 2.2). To promote inspection consistency and quality authorities are recommended to carry out regular in-house inspection meetings to assess the competence of inspectors or check that external contractors have suitably qualified/experienced inspectors who are also reviewed on a regular basis.

Preparation for Inspections

- 6.5.3 Carrying out appropriate preparatory work greatly improves the likelihood of inspections being performed successfully and efficiently and of providing the correct and accurate information. The amount of preparatory work carried out should be appropriate to the type of inspection.

Preliminary Review

- 6.5.4 Records of the structure should be reviewed to obtain a thorough understanding of what the inspection involves and to identify any specific difficulties that are likely to be encountered. For Principal and Special Inspections, it is suggested that this review includes a desk study and a reconnaissance of the structure.

Method Statement

- 6.5.5 A method statement that summarises all relevant information should be prepared and agreed before undertaking an inspection. The statement should take into account the preliminary review, access requirements, environmental considerations and Health and Safety checks. The level of detail given should be appropriate to the circumstances and the type of inspection. The following information should normally be included in the method statement:

1. Details and programme of the work to be undertaken for the inspection.

2. Equipment required.
 3. Methods of access to be used.
 4. Traffic management details.
 5. A risk assessment including safe procedures for dealing with hazards.
 6. Resources and competence of the staff to be employed.
 7. Planned working times.
 8. Temporary works to be provided.
 9. Protection from highway, railway and other traffic.
 10. Requirements for action by others.
 11. Any co-ordination or notification required.
 12. Any environmental impacts of the work.
- 6.5.6 Copies of the method statement and risk assessment should be retained for future reference. In many cases it will be appropriate for these documents to be added to the structure's Health and Safety File 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.

Undertaking Inspections

- 6.5.7 Advice on undertaking inspections of highway structures can be found in the *Bridge Inspection Guide* [8]. This should be read in conjunction with Appendix L.
- 6.5.8 An owner should decide if the inspector should, or should not, review the previous inspection report during (or immediately before) the current inspection. Using the previous inspection report may enable the inspector to focus on more critical elements. However, it may also bias the inspection process and cause the inspector to overlook defects on other elements. The experience, training and competence of the inspector should be taken into consideration when deciding on the approach to adopt. The approach agreed should be used by all highway structures inspectors and be applied consistently over time. A different approach may be adopted for each inspection type.

Recording and Reporting Inspection Results

- 6.5.9 Inspection data should be recorded in a format that gives a clear and accurate description of the structure's condition. All inspections should result in a report in a format appropriate to the inspection type. Inspection reports form the basis for identifying, assessing and prioritising maintenance in a systematic manner.
- 6.5.10 A procedure should be established whereby the inspector has a clearly defined duty to inform the bridge manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety and/or structural stability. The bridge manager should coordinate an appropriate plan of action (see Section 5.7 *Emergency Response*).

Element Condition Rating

- 6.5.11 The inspection procedure should be sufficiently sensitive to detect significant changes in condition but to avoid being overly sensitive and thus difficult for inspectors to implement effectively on site. A procedure that assesses the severity and extent of observed defects satisfies these criteria. Definitions of severity/extent of defect and guidance on their use are given in the CSS Guidance Documents on bridge inspection reporting [1 & 2]. The CSS Guidance Documents also provide descriptions of typical defects. It is recommended that the element condition rating procedure in the CSS Guidance Documents, or an equivalent and comparable procedure that is fully documented and accepted as good practice, is used for highway structures.
- 6.5.12 The observed defects and their associated severity and extent should be recorded on an appropriate pro-forma during General and Principal Inspections and, where relevant, Special Inspections.

Inspection Pro-forma

- 6.5.13 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 be able to 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.
- 6.5.14 A typical pro-forma layout for use during General and Principal Inspections is given in the CSS guidance on *Bridge Inspection Reporting* [1 & 2]. The pro-forma provides a simple and effective way of creating a consistent inspection reporting system that can be adjusted to suit the needs of individual owners.
- 6.5.15 The pro-forma may be designed to record element condition separately for each span or for all the spans/panels of a structure taken together depending on the objectives of the inspection. The former approach is to be preferred, but the latter may be sufficient for some circumstances.
- 6.5.16 An inspection pro-forma should be completed as part of a General Inspection, Principal Inspection and, where relevant, Special Inspection. It is recommended that the CSS inspection pro forma [1 & 2], or equivalent and comparable pro forma, is used for inspections of highway structures. 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 engineer may review and sign off General Inspection reports periodically and also identify maintenance needs (see Section 5.10 *Identification of needs*).

Data Capture

- 6.5.17 The core function of an inspection is to record the condition of a structure, normally by rating each element (paragraph 6.5.11), although inspections are also used to compile or verify inventory data, e.g. structure form, material type, location, route carried and obstacle crossed. Element condition data should be supported by a description of all significant defects. Methods that can be used to capture defect data on site include:

1. Traditional clipboard and pencil with a standard pro forma or pro forma printed specifically for each structure (paragraphs 6.5.13 to 6.5.16) to record text, measurements and sketches.
 2. Dictaphones to record the findings.
 3. A robust data logger or notebook computer, entering the information directly onto screens which mimic paper pro forma.
 4. Digital cameras and/or video cameras.
- 6.5.18 Digital cameras can provide an effective means of recording defects and other features of a structure. Video cameras are generally less useful in inspection work as they require a reasonable level of proficiency from the inspector, combined with subsequent editing and referencing. Video cameras can prove beneficial in particular circumstances such as recording movement or in locations where human access is difficult or expensive. In the latter scenario a video camera mounted on a boom or robot can be used, although specialist equipment is required for controlling the camera remotely and for viewing the image.
- 6.5.19 In order to identify which structure and what part of it 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.

Inspection Report

- 6.5.20 Standardised formats should be used for inspection reports. The format should be clear, follow a logical sequence and incorporate all the necessary information. The inspection reports support maintenance planning and management (Section 5) and should assist this process by adopting a relatively consistent format from one inspection cycle to the next.
- 6.5.21 A completed inspection pro-forma (see paragraphs 6.5.13 to 6.5.16) may be sufficient as the General Inspection report. Principal and Special Inspections should result in a more detailed and comprehensive report.
- 6.5.22 The report 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. The report should give due consideration to effective whole life management of the structure and provide associated recommendations on maintenance needs and programming.

Evaluation of Inspection Results

- 6.5.23 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. Section 5 (*Maintenance Planning and Management*) provides guidance on how inspection results should be used in the maintenance planning process.

- 6.5.24 The CSS Bridge Condition Indicator [9], also called the Condition Performance Indicator [10], 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.

6.6 TESTING

- 6.6.1 Testing comprises a range of activities that provide information on the condition of a structure and its behaviour. Tests include:

1. **Non-destructive Testing** - such as electrode potential measurements or ultrasonic inspection, to assist in the detection of defects that may be difficult to detect visually, such as cracks in welded joints or those hidden within the structure.
2. **Destructive Testing** - which can be subdivided into:
 - a. **Material Sampling** - methods for taking samples of materials from the structure to determine composition and properties of the material or the presence of deleterious substances such as chlorides in concrete.
 - b. **Intrusive Testing** - such as drilling holes, to determine the condition inside the structure that is not revealed by normal visual inspection, e.g. the condition of post-tensioning tendons or the interior of box sections.

- 6.6.2 There are a number of techniques that are essentially non-destructive but which may require some minor/superficial damage to be caused to the structure. An example is electrode-potential measurements on reinforced concrete. This technique requires an electrical contact to be made to the steel reinforcement. To make a contact some areas of concrete may have to be broken out to expose the reinforcement.

- 6.6.3 Tests may either be applied once or repeated periodically to monitor changes in condition and performance. The bridge manager and/or bridge engineer should have a sound understanding of the testing techniques available and be able to identify when testing may be necessary or prove beneficial. Many testing techniques are specialist activities and appropriate expert advice should be sought before employing them.

Need for Testing

- 6.6.4 The need for testing is normally identified during or following a General, Principal or Special Inspection or is required to support a structural assessment. A testing requirement generally arises from the need to:
1. Investigate, and if possible quantify, the severity and extent of a defect or damage.
 2. Investigate the cause of deterioration.
 3. Investigate the rate of deterioration.
 4. Determine the type of maintenance required and the extent of any repairs.

5. Determine material characteristics.
6. Provide data for a structural assessment.

Planning and Reviewing Testing

- 6.6.5 Specialist testing techniques can be expensive when compared to more straightforward testing techniques and inspections. Good practice is to establish a formal process for assessing testing needs and identifying effective solutions, for example:
1. **Set objectives** - clearly define the objectives of the testing.
 2. **Identify options** - identify the alternative testing options.
 3. **Compare options** - appraise and compare the identified testing options and select the most effective solution.
 4. **Review progress** - review and assess the suitability of the selected programme as the testing is undertaken.
- 6.6.6 Further advice on setting objectives, identifying options, appraising options and reviewing progress is provided in the following.

Setting the Objectives of Testing

- 6.6.7 The reasons and the objectives for testing should be clearly defined before devising a programme of tests. The objectives are likely to include the identification of the information required from the testing and how it will be used in the management of the structure.

Identification of Testing Options

- 6.6.8 Test methods are frequently identified on the basis of previous experience and engineering judgement while taking account of available guidance. Identification should also take into account advice from specialists where appropriate. The identification exercise should compile the information required to carry out the subsequent appraisal.
- 6.6.9 Information on techniques for testing concrete structures can be found in *Guide to testing and monitoring the durability of concrete structures* [11] and for timber structures in *Non-destructive testing of timber* [12].
- 6.6.10 Information on the application of a wide range of testing techniques is available in British Standards. The BS EN 12504 series testing concrete in structures [13] includes standards for NDT techniques for inspecting concrete. There are no similar series of standards for inspecting structural steel. However, Series 1800 of Volume 1 'Specification for Highway Works' in the *MCDHW* [7] refers to appropriate standards. Also, *Steel Bridge Group: Guidance Notes on Best Practice in Steel Bridge Construction* [14] includes a section on the inspection and testing of structural steel. There is limited advice available on some of the less well-known techniques and on those that are at the research stage. These techniques should be applied only by those with specialist knowledge of the technique.

6.6.11 Whilst the above standards provide guidance on the correct application of the techniques, they provide only limited assistance on selecting the most suitable methods for particular problems being investigated and on interpreting the results. Some advice on the selection and procurement of NDT methods for particular applications can be found in *BA 86 Advice Notes on the Non-Destructive Testing of Highway Structures* [15].

Appraisal of Testing Options

6.6.12 Testing should not be considered in isolation but should be regarded as one facet of data collection. Testing should complement the drawings, inspection records, previous test data, structural form, material type and the history of the structure. It is therefore normal for testing programmes to include a range of tests. Devising a test programme is inevitably a compromise between costs and obtaining an adequate set of information.

6.6.13 The following should be considered when appraising the testing options:

1. Effective combination of testing techniques, e.g. ducts in post-tensioned concrete construction may be located by specialist probes or radar in preparation for intrusive drilling and sampling. Another example of the benefit of using different techniques in combination is where a simple test may be used to survey the whole or large areas of a structure, followed by more refined testing of a representative sample of locations having a particular characteristic, e.g. high chloride content.
2. The risk of damage to the structure from destructive (sampling or intrusive) investigations. The removal of samples or formation of access holes for inspection and the subsequent repair should be carefully specified and supervised, to avoid potentially serious damage to the structure or the creation of points of weakness that are vulnerable to deterioration in the future.
3. The need for calibration and return visits to site. Testing techniques generally require calibration and the results may not always be definitive. Consequently a return to site after analysis of early test data may be required.

6.6.14 Experience has shown there is often a wide variation in the number and type of tests selected for the same objective. This variation results from a lack of guidance and the natural tendency to base specifications on previous contracts, which may lead to the inclusion of tests that are not strictly necessary. Care should be taken to avoid 'a shopping list' approach whereby, to obtain as much information as possible, all the techniques available for a particular problem are applied. This approach results in unwarranted expenditure that provides a surplus of data, much of which adds little to the investigation in hand. A problem solving approach, that assesses costs and benefits, should be adopted and the selection of techniques should be restricted to those that can add value to the investigation.

6.6.15 Care should always be taken when preparing a specification for testing work, and during the site work and interpretation stages, to check that all factors likely to influence the interpretation of results are understood and allowed for. Prior approval should be obtained from the bridge manager when destructive testing is required.

Reviewing Testing

- 6.6.16 A cautious approach should be adopted for the implementation of testing. Where appropriate, it is advisable to test a small, but representative, area/part of a structure initially and use this to assess the usefulness of the technique and results. Testing programmes can only be provisional, and may require amendment as a result of initial testing and interpretation. Staged testing, permitting interpretation of results between each stage, should be considered in all cases. However, the use of staged testing could lead to significantly increased access costs and this should be taken into account in these considerations.

Testing for Structural Assessment

- 6.6.17 Information derived from testing can usefully supplement available data to support an assessment of load carrying capacity. The testing may involve simple measurements to confirm the structural dimensions or sampling of materials to enable their structural properties to be determined. Advice on material sampling for assessment can be found in *BA 44 Assessment of Concrete Highway Bridges and Structures* [16] and *BA 56 The Assessment of Steel Highway Bridges and Structures* [17].
- 6.6.18 More sophisticated testing can be used to investigate construction details, e.g. to determine the size and location of reinforcement in concrete or to determine the presence of internal features such as voids or internal spandrel walls in masonry arch structures.
- 6.6.19 Load testing can also be used to obtain information on how structures behave under load. Two types of load testing are available, supplementary load testing and proving load testing.

Supplementary Load Testing

- 6.6.20 Supplementary load testing can be used to provide information on how a structure distributes loads through its various members. The purpose of supplementary load testing is to improve upon the predictions made by standard theoretical models and techniques. The levels of load applied are such that they will be sufficient to obtain a satisfactory measurable response from the structure without causing any permanent structural damage. It is unlikely that such low loading will exceed the loads experienced by the structure under normal conditions of use.
- 6.6.21 Supplementary load testing offers the possibility of developing a more realistic analytical model for structural behaviour based on measured rather than theoretical values of stiffness parameters. It is also used where there is the possibility of mobilising structural actions which are not considered during a normal theoretical assessment, but which can contribute to the load carrying capacity of the structure. In both cases there is a proviso that no significant risk is created during the test that the structure will be damaged. Caution is required in extrapolation of test results carried out at fairly low levels of load compared to those likely to occur at the ultimate limit state, since structural behaviour is likely to change as the load is increased to ultimate. Supplementary load testing should only be used to predict load bearing capacity where evidence that change of behaviour does not occur is available, e.g. *The assessment of filler beam bridge decks without transverse reinforcement* [18].

- 6.6.22 The positions of the loads applied during the test and the location and type of instrumentation used depend on the objective of the test. If, for example, the test is to determine the amount of composite action taking place in a bridge deck, it is necessary to record surface strains across the full depth of the section.
- 6.6.23 Advice on the use of supplementary load testing can be found in *BA 54 Load testing for bridge assessment* [19]. Detailed information on undertaking supplementary load testing is given in *Guidelines on the Supplementary Load Testing of Bridges* [20].

Proving Load Testing

- 6.6.24 Proving load testing is intended as a self-supporting alternative to theoretical assessments, carried out subsequent to such assessments. In proving load tests, the load is increased in increments to some predetermined maximum or until the elastic limit is reached. The safe load carrying capacity is then derived from the maximum test load by reducing it by an appropriate factor.
- 6.6.25 Proving load tests require considerably higher levels of loading than supplementary load testing and consequently expose a structure to a higher likelihood that it may be irreversibly damaged during the test. In view of this, and pending further research, proving load tests are not recommended [BA 54; 19].

Selection of Test Houses and Specification and Procurement of Testing

- 6.6.26 Where testing expertise is not available in-house, the testing and monitoring of highway structures should be undertaken by specialist test houses. Guidance on the selection of test houses and the specification and procurement of testing is given in Appendix M.

Recording and Reporting of Test Results

- 6.6.27 A report should be provided by those undertaking tests, giving full details of the testing. The report should include, but not be restricted to:
1. The objectives of the testing.
 2. A full description of the equipment used including details of calibration and accuracy.
 3. A copy of the method statement which should include, but not be restricted to, methodology, location of measurements, grid size (where appropriate), number of measurements at each location and a copy of any risk assessment (where appropriate).
 4. The date of the testing and the conditions under which it was applied.
 5. The test locations and location referencing system. This system should be in sufficient detail to clearly identify the test locations and to enable the tests to be repeated at the same location, if required in the future.
 6. The raw test data.
 7. An interpretation of the data.

8. Any other observations that are considered relevant.
 9. Videos, photos, diagrams and sketches, as appropriate, that support the above points and help the reader understand details of the testing.
- 6.6.28 The results should be presented in a format that can be clearly understood and relates to the construction form and material of the structure. The interpretation of test results should use the data obtained from testing and any background material available. Where appropriate a diagrammatic interpretation of the results should be provided.

Evaluation of Test Results

- 6.6.29 All the information relevant to the problem under investigation should be assembled before attempting to evaluate the results of testing. The information to hand should include details of the structure and results of inspections and any previous testing.
- 6.6.30 Some tests provide factual data, e.g. properties of materials taken from the structure, depth of cover to reinforcement and paint thickness. Other tests require specialist interpretation, e.g. electrode potential measurements or the results of radar surveys. The specialists making the interpretation should be provided with any additional information that may assist them, e.g. structural drawings showing the layout of the reinforcement helps the interpretation of radar surveys.
- 6.6.31 Whilst the test house may be best placed to provide a practical interpretation of the results, the ultimate responsibility for the interpretation of tests and any consequent maintenance action lies with the authority who commissioned the tests.
- 6.6.32 It may sometimes appear desirable to undertake further testing before coming to a decision on what action to take. Careful consideration should be given as to whether additional testing will be of benefit. Testing does not always provide quantitative information on structural condition and the interpretation nearly always includes an element of engineering judgment.

6.7 MONITORING

- 6.7.1 Monitoring is the periodic, or continuous, measurement of structural behaviour by visual or electronic means, e.g. deflections, strains and crack sizes. There are many instances where measurements can usefully be repeated periodically, or in rare circumstances taken continuously, so that condition and performance can be monitored over time.

Need for Monitoring

- 6.7.2 Key reasons for undertaking monitoring include:
1. During construction to check behaviour.
 2. After construction as an aid to the future maintenance management.
 3. Where deterioration or damage has occurred and it is necessary to check for further loss of strength, condition or performance.

4. On structures that, when assessed to modern codes, have a load-carrying capacity that is below current standards but do not appear to be suffering distress.

Selection of Monitoring Techniques/Design of Monitoring Systems

- 6.7.3 Monitoring covers a wide range of applications, from determining the ingress of chlorides into concrete over a period of years to the transient behaviour of a structure as a heavy vehicle passes over it. Typically monitoring systems may be put in place to determine long-term movements, crack growth, changes in strain (either long-term or short-term) or the corrosivity of the environment.
- 6.7.4 The techniques used depend on the reasons for monitoring, which should be clearly defined at the outset. The aim should be to install the simplest monitoring system that meets the objectives, providing it is sufficiently robust for the specific location. The following issues should be considered when selecting a monitoring system.

External Factors

- 6.7.5 When devising a monitoring system consideration should be given to monitoring the external factors that may influence the property being measured. Temperature, for example, has a major influence on both structural behaviour and the various deterioration mechanisms that occur in highway structures.

Complexity of System

- 6.7.6 The simplest systems comprise visual checks or gauges which can be read manually, e.g. crack width gauges or mechanical strain gauges, such as Demec gauges. Where higher accuracies are required other types of sensor, such as vibrating wire strain gauges, may be used.

Data Collection Frequency

- 6.7.7 Where access is difficult or more frequent measurements are required, e.g. to monitor changes due to temperature, it may be necessary to install sensors that can be connected to a data logging system. This is particularly advantageous in those cases where access causes traffic disruption. It is important to consider how the data will be collected, e.g., it could be downloaded locally by visiting the site, or remotely through telephone lines.
- 6.7.8 The interval between readings depends on what is being monitored and the rate at which it is likely to change, e.g., it might be appropriate to repeat certain types of measurement, such as the determination of chloride concentration, every time a Principal Inspection is carried out. Other types of measurement might need to be repeated more frequently, e.g. monitoring crack widths might require weekly or monthly measurements. Monitoring temperatures or strains might require measurements every hour and recording transient strains might require measurements to be taken several times a second.

- 6.7.9 Most monitoring systems can collect data at regular intervals for the period of the monitoring but in other cases data is collected only when an event triggers the monitoring system. An example is the detection of wire fractures in post-tensioned structures using acoustic monitoring. The structure is monitored continuously but data is recorded only after an acoustic event is detected that has the characteristics of a wire break. Another example is the measurement of stresses under traffic loading where the monitoring system is triggered by heavy vehicles and data is collected only during their passage over the structure.



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- 6.7.10 Monitoring systems can also be designed to process data as it is being collected from the instrumentation. With this setup, if the system is connected by telephone or other transmission system, it can be designed to act as an early warning device, automatically issuing an alarm when pre-defined limits of the parameters are reached. This type of system can be used effectively as part of a risk management strategy.

Scour

- 6.7.11 Advice on the monitoring of highway structures for scour is given in *Manual on scour at bridges and other hydraulic structures* [1]. Scour monitoring and inspection are not straightforward because scour is not normally visible during a flood and scour holes often fill in during the falling stages of a flood. As a result it can be difficult to assess in flood conditions the magnitude of scour holes and determine whether the structure is safe.

Retaining Walls

- 6.7.12 Monitoring the performance of retaining walls can be carried out by measuring movements directly, but sometimes it is more appropriate to use inclinometers, or electro-levels. Loads and moments in walls can be measured using pressure cells and strain gauges. Associated behaviour of the nearby ground can be monitored using inclinometers, pressure cells and piezometers. Installation and monitoring of these devices is a skilled operation and recourse should be made to a specialist.

Installation

- 6.7.13 Key issues that need to be addressed when considering the installation of a monitoring system include:
1. The environment both on and adjacent to highway structures is particularly aggressive so the site equipment must be sufficiently robust to withstand this and the weather for the duration of the monitoring period.

2. The system will need to be maintained and the power source will need to be either battery or mains with battery back-up. If batteries are used, they need to be accessible to enable them to be replaced periodically.
 3. The data logging capacity will need to be sufficient to store the required data between downloads.
 4. Protection against vandalism is a major consideration when designing a monitoring system. The data logging system and other equipment such as batteries should be placed in a secured lockable cabinet, although the wiring and sensors may be more difficult to protect. Wherever possible the system and other equipment should be placed where they are not easily accessible and are hidden from view.
- 6.7.14 Details of the monitoring system should be included in the Structure File and Health and Safety File, if appropriate, so that others working on the structure are aware of its presence.

Monitoring of Sub-standard Structures

- 6.7.15 Monitoring can be used on structures that fail a strength assessment thus avoiding the disruptive effect of applying other formal interim measures. Advice on the use of monitoring in these circumstances is given in Section 7.7.

Evaluation of Monitoring Results

- 6.7.16 Monitoring a highway structure should not be an end in itself but part of a wider strategy for management.
- 6.7.17 Where simple factual information is being collected, such as ingress of chlorides into concrete over time, the information can be readily interpreted in the light of other information to hand about the structure. However, most information requires an initial evaluation to enable conclusions to be drawn on what is being measured. Initial evaluation is required particularly where external factors such as temperature may affect the parameter being investigated. Both the monitoring system and the behaviour of the structure are affected by temperature and separating the influence of the different factors can be quite complex and may require specialist advice from the outset of design of the monitoring system.
- 6.7.18 Monitoring may generate large volumes of data and consideration needs to be given at the outset to its storage, analysis and eventual presentation. It is important to focus on what is needed and avoid becoming immersed in data.

Recording and Reporting of Monitoring Results

- 6.7.19 A detailed record should be kept of the monitoring system. The record should include objectives of the monitoring, the equipment used, the location and position of sensors and data logging system (where appropriate), procedures for maintaining the system and collection of data, where the data is stored and how it is analysed.
- 6.7.20 Where necessary, sensors should be calibrated before use and the calibration records maintained in the Structure File for future reference.

6.8 RECOMMENDATIONS AND ACTIONS

6.8.1 It is recommended that an inspection regime should be implemented for all highway structures, supplemented by testing and monitoring where appropriate. The inspection regime should include Acceptance, Routine Surveillance, General, Principal, Special and Safety Inspections as necessary.

6.8.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Implement a regime of Routine, Safety, Special and Acceptance Inspections covering all highway structures and any necessary testing and monitoring (Section 6.4). • Implement a regime of General Inspections at an interval of not more than two years covering all highway structures (Section 6.4). • Implement a process whereby the inspector has a clearly defined duty to inform the bridge manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety (Section 6.5). • Implement a monitoring regime for all sub-standard structures (Section 6.7).
TWO	<ul style="list-style-type: none"> • Implement a regime of Principal Inspections at an interval of not more than six years covering all highway structures except those where a Principal Inspection would not add significantly to the defects picked up by a General Inspection (Section 6.4). • Record the severity and extent of defects during General and Principal Inspections. It is recommended that the CSS Inspection Guidance, or a similar approach, is used (Section 6.5). • Produce a full report for each Principal Inspection (Section 6.5). • Carry out regular in-house inspection meetings to assess the consistency and competence of inspectors OR check that external contractors have suitably qualified/experienced inspectors who are also reviewed on a regular basis (Section 6.5).
THREE	<ul style="list-style-type: none"> • Implement a regime of Principal Inspections covering all highway structures. Where appropriate, use risk assessment to determine the inspection interval (Section 6.4). • Produce an inspection, testing and monitoring manual that clearly defines the inspection requirements for the authority with H&S, Environmental and Conservation information recorded for each structure (Sections 2 and 6).

6.9 REFERENCES FOR SECTION 6

1. *Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting*, County Surveyors Society, 2002.
2. *Addendum to CSS Bridge Condition Indicators Volume 2*, County Surveyors Society, 2004.
3. *BA 50 Post-tensioned Concrete Bridges, Planning, organisation and methods for carrying out Special Inspections*, DMRB 3.1.3, TSO.
4. *BA 63 Inspection of highway structures*, DMRB 3.1.5, TSO.
5. *BD 63 Inspection of highway structures*, DMRB 3.1.4, TSO.
6. *BD 21 The Assessment of Highway Bridges and Structures*, DMRB 3.4.3, TSO.
7. *Manual of Contract Documents for Highway Works (MCDHW)*, TSO.
8. *Bridge Inspection Guide*, HMSO, 1983.
9. *Bridge Condition Indicators Volume 3: Guidance Note on Evaluation of Bridge Condition Indicator*, CSS, 2002.
10. *Guidance Document for Performance Measurement of Highway Structures – Part B1: Condition Performance Indicator*, Version 1.3, February 2005, Draft Working Report.
11. *Guide to testing and monitoring the durability of concrete structures*, Concrete Bridge Development Group Technical Guide 2, Concrete Society, 2002.
12. *Non-destructive testing of timber*, TRADA Technology Reference WIS 4-23, 2004.
13. *BS EN 12504 Series Testing of concrete in structures*, BSI.
14. *Steel Bridge Group: Guidance Notes on Best Practice in Steel Bridge Construction*, J E Evans and D C Iles, Steel Construction Institute, 2002.
15. *BA 86 Advice Notes on the Non-Destructive Testing of Highway Structures*, DMRB 3.1.7, TSO.
16. *BA 44 Assessment of Concrete Highway Bridges and Structures*, DMRB 3.4.15, TSO.
17. *BA 56 The Assessment of Steel Highway Bridges and Structures*, DMRB 3.4.12, TSO.
18. *The assessment of filler beam bridge decks without transverse reinforcement*, Low, A M C C & Ricketts, N J, TRL Research Report Special RR 383 Transport Research Laboratory, 1993, ISBN 0952186004.
19. *BA 54 Load testing for bridge assessment*, DMRB 3.4.8, TSO.

20. *Guidelines on the Supplementary Load Testing of Bridges*, National Steering Committee for the Load Testing of Bridges, The Institution of Civil Engineers, London, 1998.
21. *Manual on scour at bridges and other hydraulic structures*, Publication C551, CIRIA, 2002.

Section 7

Assessment of Structures

This section provides guidance on the principles and standards for the structural assessment of highway structures, the recording of assessment results, and making appropriate recommendations with respect to substandard structures. A regime for structural review and reassessment of structures is recommended, and guidance is given on the assessment process to be followed.

7.1 PURPOSE

- 7.1.1 The purpose of the assessment of a highway structure is to determine the ability or capacity of the structure to carry the loads which are imposed upon it, and which may reasonably be expected to be imposed upon it in the foreseeable future. The assessment provides valuable information for managing the safety and serviceability of highway structures.

7.2 REQUIREMENTS

- 7.2.1 A regime of structural reviews should be implemented whereby the adequacy of structures to carry the specified loads is ascertained when there are significant changes to the usage, loading, condition or the assessment standards. A structural review should identify structures which need a detailed assessment.



- 7.2.2 A prioritised programme of structural review should be put in place to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards. Where a requirement for assessment is identified, such assessments should be carried out in accordance with national standards which are current at the time.
- 7.2.3 The results of assessments and structural reviews should be recorded, together with relevant data and assumptions, and kept up-to-date and utilised in the planning and management of future maintenance programmes on the structures.

7.3 BASIS AND PRINCIPLES

Structural Review

- 7.3.1 A review of an individual structure or group of structures, within the structures stock, to establish or confirm the validity of its latest assessment (or its original design if there has been no subsequent assessment) is termed a 'structural review'. A structural review should consider all available current information, taking account of the known condition of the relevant structures, their inherent strengths and weaknesses and anticipated effects of any changes, including changes to assessment standards. A structural review should not normally require detailed analysis of particular structures.
- 7.3.2 Assessment and structural review are key elements of the management process for highway structures to check their safety and serviceability. All structures should therefore be assessed or reviewed against current national standards.
- 7.3.3 Highway structures should have a regime of ongoing structural reviews to consider their adequacy to support imposed loads. Such reviews should be undertaken when significant events occur that could increase the imposed loads above those previously assessed for and/or reduce the load bearing capacity due to deterioration or accidental damage. The impact of new knowledge or information and changes to codes and standards should initially be examined through a structural review before a detailed assessment is initiated. Such reviews should take account of relevant guidance in any new code or standard.

Assessments

- 7.3.4 Since detailed assessments require considerable effort, an assessment should only be undertaken when a structural review has identified the need for assessment.
- 7.3.5 The assessment should take account of all available information about the structure including its service performance. In addition, an 'Inspection for Assessment' (see paragraph 7.5.9) should be performed to establish the current condition of key structural elements as accurately as is practicable.
- 7.3.6 The scope of assessment and method of analysis used should be commensurate with the form of the structure, information available and the consequences of a potential shortfall in the assessed load bearing capacity. Assessment of simple structures not showing signs of distress, particularly if details of the hidden parts of the structure are unknown, may be based solely on inspection as permitted by current standards. This would include mass concrete or masonry retaining walls that did not show signs of bulging, cracking, deformation, tilting etc.
- 7.3.7 Assessment should generally be carried out initially using simple but conservative analytical methods. Where the adequacy of a structure cannot be confirmed, or falls short of requirements using simple methods, progressively more precise and advanced methods should be employed where it is judged that a desired increase in assessed load bearing capacity might reasonably be achieved.

7.4 STRUCTURAL REVIEW AND ASSESSMENT REGIME

7.4.1 The future management of highway structures should include a regime of ongoing structural reviews to ascertain their adequacy to support imposed loads. Such reviews should be undertaken when significant events occur that could increase the imposed loads above those previously assessed for and/or reduce the load bearing capacity of structures. A structural review should be undertaken, for example, when one or more of the following conditions or events occur:

1. The structures are known or suspected to have load bearing capacities below those deemed to be appropriate for the class of highway supported.
2. There is a significant change in the regulations governing the configurations and weight limits of vehicles which may use the relevant highway. The impact of such changes would generally have been assessed by the Department for Transport or the Highways Agency and guidelines issued to authorities on the actions to be taken.
3. The hierarchy of the road carried by the structure has changed or is proposed to be changed. The change may modify the density and type of traffic carried resulting in a change to the 'loading class' defined in *BD21 The Assessment of Highway Bridges and Structures* [1].
4. Records of the original design or subsequent assessment do not exist or have become discredited.
5. The structure has been modified or is proposed to be modified.
6. The structure is on a route proposed for an abnormal load movement, either a Special Order vehicle or an un-common STGO vehicle, for which the structure has not been previously assessed.
7. Significant deterioration or damage has been identified by an inspection. Conditions considered would include those found in structures such as arches which may be susceptible to changing condition factors.
8. At least every 12 years, in conjunction with a Principal inspection.

7.4.2 Many highway structures have already been assessed. A prioritised programme of structural review should be put in place to establish the validity of existing assessments, the appropriate periods of review and the need for new assessments for structures that have not been assessed to current standards. The following priorities are suggested in the absence of any other information:

1. Structures with suspected load bearing capacities below those deemed to be appropriate for the class of highway supported.
2. Structures built prior to and including 1975, unless known to have been designed to *Technical Memorandum (Bridges) BE 1/73 Reinforced Concrete for Highway Structures* [2] where appropriate. 1975 broadly corresponds to the cut off for Stage 2 of the Highways Agency's assessment programme in the 1990's, which picked up bridges not designed to the then reinforced concrete shear design rules in BE 1/73.
3. Reassessment of structures that have passed the 40 tonne Assessment Live Load requirement, to determine their capacity to carry abnormal loads.

4. Structures built between 1975 and 1985. This period saw significant increases in the HA (normal traffic) loading associated with HB (abnormal) loading and the implementation of *BS 5400; Steel, concrete and composite bridges* [3].
5. Structures built after 1985, if deterioration or other factors indicate the structure may not meet the required operational load bearing capacity and structural integrity may be compromised. Current highway design loading has remained effectively unchanged since *BD 37 Loads for Highway Bridges* [4] was first published in 1988. However, during the previous two to three years various interim design standards were in place such that 1985 is believed to represent a reasonable date to assume for the introduction of the current design loading criteria.

7.4.3 A structural review should identify whether a detailed assessment is needed.

7.4.4 Assessment of individual structures should generally follow the process recommended in Section 7.5.

7.5 ASSESSMENT PROCESS

7.5.1 The assessment of a highway structure requiring detailed structural analysis should generally include the following key steps:

1. Establish need.
2. Appoint the assessor and define initial scope.
3. Gather information.
4. Initial appraisal (typically using a Level 1 analysis according to *BA 79 The Management of Sub-standard Highway Structures*).
5. Establish current condition (inspection and testing).
6. Technical Approval (Approval in Principle Application defining level of assessment, assumptions to be made and checking requirements).
7. Appoint the checker.
8. Formal Assessment Analysis and Checking.
9. Determine any remedial actions.
10. Assessment Report and Certification.
11. Management review to determine appropriate action.

7.5.2 This process is illustrated in Figure 7.1. Further guidance on some of the steps involved is given below.

Establish Need

7.5.3 The need for assessment should be established through a structural review as described in paragraph 7.4.1.

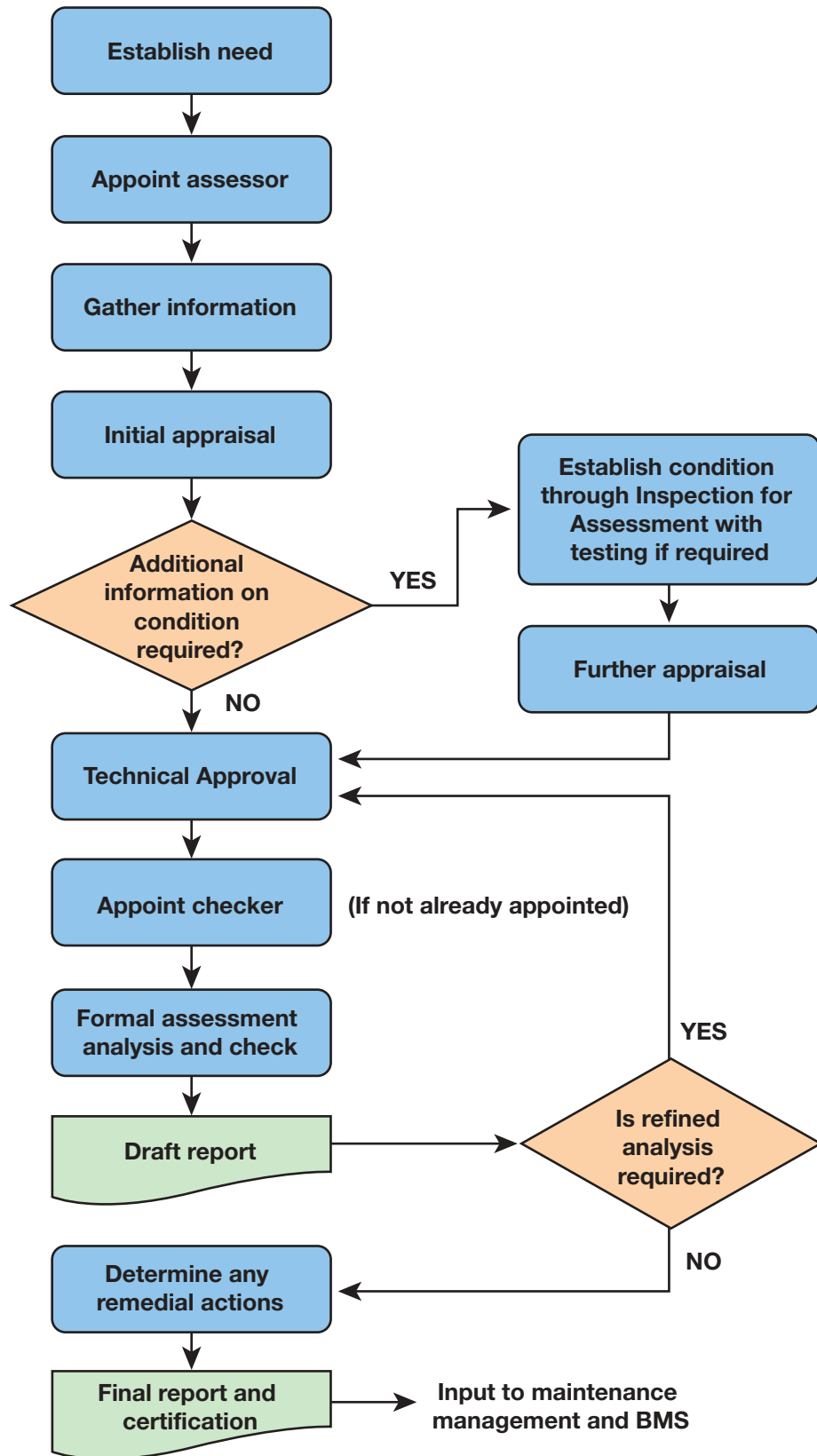


Figure 7.1: Flowchart of the assessment process for a highway structure

Initial Appraisal

- 7.5.4 Most assessments require an initial appraisal to establish what level of assessment is required and whether any additional information in the form of further inspections or testing is needed. The form of this appraisal may vary, but may include a Level 1 analysis. The five levels of assessment are described in Table 7.1.
- 7.5.5 When sufficient information has been obtained the appropriate scope of the assessment should be formally agreed between the overseeing manager and the assessor and be subject to a Technical Approval process. The appropriate scope of assessment may range from a judgement based simply on the Inspection for Assessment for a small retaining wall, as allowed by *BD 21 The Assessment of Highway Bridges and Structures* [1], to a detailed structural analysis of all parts of a structure based on information from records, inspections and investigations.
- 7.5.6 Structures that have not previously been assessed generally require an assessment of all load bearing elements. Assessments arising out of identified local damage and/or deterioration may only require assessment of a limited number of elements that lead towards the design of a suitable repair. Depending on the circumstances, there may be variations in traffic loads that may need to be considered.
- 7.5.7 A check-list of questions to be resolved in defining the initial scope of an assessment includes:
1. How much of the structure is to be considered?
 2. Are the abutments and wing walls to be assessed?
 3. Are intermediate supports to be assessed?
 4. Are piles to be assessed?
 5. Are parapets to be assessed?
 6. Is additional inspection or testing required?
 7. What loading conditions and assessment load levels should be considered?
 8. Are abnormal loads/STGO vehicles to be considered?
 9. Are there any specific abnormal loads to be considered?
 10. Is vehicular impact to columns and/or superstructure to be included?
 11. What level of checking is to be employed and by whom?
 12. Are there any other requirements?
- 7.5.8 The assessment standards provide further advice on the above issues.

Inspection and Testing for Assessment

- 7.5.9 The general requirements for inspections and testing of highway structures are covered in Section 6 (*Inspection, Testing and Monitoring*).
- 7.5.10 The report on the Inspection for Assessment should include the observations made and comment on the condition of the structure, giving the condition factors required by *BD21 The Assessment of Highway Bridges and Structures* [1]. If the condition has deteriorated since the previous inspection, a statement should be included on its importance and, if appropriate, how the deterioration should be taken into account in the assessment calculations. For example, a condition factor might be used or the assessment might be based on a deteriorated (smaller) section of structural elements.

Technical Approval

- 7.5.11 Technical Approval is the formal arrangement by which the Technical Approval Authority (TAA) agrees the basis on which a structural design or assessment is to be carried out. It confirms the scope and level of the assessment together with the standards to be used and the forms of analysis models that are to be used. Technical Approval extends to formal acknowledgement of completion by the acceptance of appropriate certification.
- 7.5.12 An appropriate system of Technical Approval should be established and an organisation or individual should be formally appointed to act as the TAA on behalf of the owner.
- 7.5.13 The system for both design and assessment identified in *BD 2 Technical Approval of Highway Structures* [5] is recommended and key features are summarised below.
- 7.5.14 At the outset of the assessment process the assessor produces an Approval-in-Principle (AIP) form. This form has a standard format and identifies a number of details relevant to the assessment including:
1. Highway details.
 2. Site details – obstacles crossed.
 3. Details of the structure to be assessed, including the material strengths.
 4. Assessment criteria – loading requirements and reference to appropriate standards and any proposed departures from those standards.
 5. Details of structural analysis.
 6. Geotechnical conditions/assumptions.
 7. Checking requirements and definition of the form of certificates required.
 8. A list of drawings, inspection and test reports included with the AIP.
 9. Details of the assessment team submitting the AIP.
 10. Details of the TAA approving the AIP.

- 7.5.15 The authority and the TAA should jointly maintain an up-to-date list of current design and assessment standards similar to those listed in Annex B of BD 2.

Formal Assessment Analysis

- 7.5.16 The analysis of a structure to determine its load bearing capacity should employ an approach that is appropriate for the structural form and materials as recommended by national standards.
- 7.5.17 The five Levels of Assessment as defined in Advice Note BA 79 *The Management of Sub-standard Highway Structures* [6] should be considered. These Levels are summarised in Table 7.1 below.

Level	Requirement
1	Use of simple analysis methods and full partial safety factors from appropriate assessment standards to produce a conservative assessment
2	Use of a more refined analysis model such as grillage or finite element models. Also allows the determination of actual characteristic strengths based on existing test data deemed to be relevant to the particular structure.
3	Allows the use of Bridge Specific Assessment Live Loading (BSALL). Also allows the use of characteristic strengths or worst credible strengths based on testing of samples of materials from the structure.
4	Requires a review of the implicit levels of safety being applied and the amendment of the assessment criteria for any additional safety characteristics inherent in a particular structure or group of structures.
5	Requires reliability analysis of a particular structure or structure type.

Table 7.1: Levels of Assessment

- 7.5.18 The level of analysis should be appropriate to the circumstances. Where initial assessment does not provide the required confidence in the structure, progressively more advanced methods should be employed, taking into account the cost of more advanced analysis and the benefits that might reasonably be gained.
- 7.5.19 Level 1 may be used for initial assessments, leading to subsequent Level 2 or 3 assessments. Level 1 should only be relied upon as a definitive assessment if it clearly demonstrates the required load bearing capacity of the structure.
- 7.5.20 Levels 2 or 3 generally provide the degree of confidence required to establish the load bearing capacities of most structures. The additional testing associated with Level 3 should be dependent on whether or not such evidence might reasonably increase the assessed load bearing capacity to a level which is considered appropriate or desirable for the particular structure.
- 7.5.21 Levels 4 and 5 can only be expected to produce marginal improvements in load bearing capacity over Level 3, but may be warranted in special cases. Use of Level 5 assessment requires specialist knowledge of reliability analysis and is only warranted if there is likely to be a significant cost benefit.

- 7.5.22 Where practicable, assessment should include an estimate of any reserve load bearing capacity of the structure. Where there is likely to be ongoing deterioration of a structure, assessment should include the determination of critical condition factors.
- 7.5.23 Where the assessment indicates that a structure is substandard in relation to the requirements of current standards, remedial options should be considered, appraised and a final action recommended. Interim measures (including those necessary to protect the structure and the public) to be taken prior to the implementation of the recommended remedial action, including restriction of use or monitoring if appropriate, should be recommended. See also Section 7.7.3.

7.6 RECORDING OF ASSESSMENT RESULTS

Assessment Report

- 7.6.1 Structural assessment results should be fully detailed in a formal report which should provide the following information as a minimum:
1. The name, location and any formal identification number of the structure.
 2. For bridges, details of obstacles crossed and roads carried.
 3. The date and reason for the assessment.
 4. An overview of the method of analysis including a description and diagram of any computer model used.
 5. Any appropriate geological assumptions and parameters.
 6. Loading details.
 7. Level of assessment.
 8. Overall assessed load bearing capacity.
 9. Identification of any critical elements of the structure.
 10. All condition factors used and if relevant, the pavement condition or other variable factors which formed part of the assessment.
 11. Recommendations in respect of any elements having an assessed load bearing capacity below that required or considered desirable.
 12. Guidance on timescale for which the assessment results are expected to be valid and the date or specific circumstances for undertaking a subsequent structural review.
 13. The signed AIP and accepted certification should be included in an appendix together with the assessment calculations or reference to other documents containing the calculations.

Basic Records for the Bridge Management System

- 7.6.2 The basic results of an assessment should be recorded in a standard format common to all of the structures for which the authority is responsible. Ideally the record would take the form of an electronic database.
- 7.6.3 The level of detail transcribed from the assessment report into the database should be defined by the Bridge Management System adopted by the authority. This could include basic details of each structure including location, form of structure, details of road(s) carried, span arrangements, and designed or assessed load bearing capacity. These requirements are described in more detail in Section 9 (*Asset Information Management*).
- 7.6.4 Where the results of the assessment are dependent on variable factors such as pavement condition, as allowed by BD 21, there should be a clear feedback to the highway authority to ensure that the ongoing requirements form part of the planning process for periodic maintenance. In such cases, committing to a protocol that ensures good stewardship of the surface quality can lead to the benefit of an increased load bearing capacity rating for the bridge. However, poor condition should generally be assumed if that commitment can not be assured.
- 7.6.5 Information on reserves in load bearing capacity with respect to both normal and abnormal traffic loading, where available, and critical condition factors for elements susceptible to deterioration should be used in the planning and management of future maintenance programmes on structures.

Additional Records for Critical Structures

- 7.6.6 A structure that has a load bearing capacity below those of others on a particular section of road is termed a 'critical structure'. If the load bearing capacity of a critical structure is below that required for unrestricted normal traffic (typically the 40 tonne Assessment Loading defined in *BD 21* [1]), it will effectively restrict the whole section of the road to this weight limit. Alternatively, a structure may be critical with respect to the movement of abnormal loads (see Section 8). In either case, it is useful to record additional information from the assessment to aid consideration of what vehicles should or should not be allowed to use the road.
- 7.6.7 The additional information recorded for critical structures (particularly bridges) could include:
1. Details and load bearing capacities of all potentially critical elements with live load capacities up to 15% higher than the governing element/capacity.
 2. Load ratings in terms of HB units and all relevant Reserve Factors against SV vehicles as defined in *BD 86 The Assessment of Highway Bridges for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles* [7].
 3. If practicable, lane influence lines for critical effects together with the associated limiting load bearing capacities.
 4. For arches, details of the bogie configurations considered and their associated maximum axle loads.

7.7 INTERIM MEASURES AND MANAGEMENT OF SUBSTANDARD STRUCTURES

- 7.7.1 A structure which does not meet the requirements of standards used in its assessment is termed a 'substandard structure'. The assessment of a substandard structure should identify the appropriate remedial action required to maintain its safety.
- 7.7.2 Prior to strengthening or replacement, all substandard structures should be considered as representing a risk to the public. Where such works have to be deferred, detailed risk assessments should be undertaken and where appropriate interim measures should be implemented as soon as possible.
- 7.7.3 If there is deemed to be an immediate risk to public safety, *BD 21* [1] and *BA 79* [6] require that formal interim measures which would effectively mitigate the risk, be put in place until the identified remedial action is implemented. These measures may include:
1. Weight or width restrictions plus monitoring.
 2. Propping or temporary bridge plus monitoring.
 3. Closure and diversion of traffic.
 4. Deterring vehicles over-running substandard areas of structures.
- 7.7.4 *BA 79* [6] also provides guidance on the short to medium term management of structures where the immediate application of any of the above measures may not be practicable.
- 7.7.5 In particular *BA 79* [6] provides guidance on the use of weight restrictions and/or the application of monitoring to appropriate structures, and provides a Technical Approval framework for agreeing such measures.
- 7.7.6 *BA 79* [6] indicates that structures that satisfy **all** the criteria in 1, 2 and 3 below and additionally small span bridges as described in 4, may be considered to be appropriate for monitoring subject to Technical Approval.
1. Structures with no significant signs of distress, or structures where distress is observed which does not appear to be recent or significant and detrimental to the safety of the structure.
 2. Structures where failure is likely to be gradual over time, progressing from local signs of distress to more extensive failure before reaching the point where total collapse is precipitated. It must also be possible to predict the mode(s) of failure under traffic load with reasonable certainty.
 3. Structures and situations where monitoring would be meaningful and effective.
 4. Bridges of spans less than 5 metres where the consequences of failure are low.
- 7.7.7 The Highways Agency commissioned a review of *BA 79* [6] which provided a number of recommendations. At the time of this Code going to press the

Highways Agency were reviewing the recommendations and this may result in a revision of *BA 79* [6].

7.8 ASSESSMENTS FOR ABNORMAL LOADS

- 7.8.1 Assessment for the effects of abnormal loads on bridges and other highway structures should be carried out in accordance with *BD 86* [7]. This standard is based upon a series of “SV” loading models which more closely model the behaviour of real heavy vehicles than the old HB model, and defines how a Reserve Factor should be calculated for each acceptable vehicle.
- 7.8.2 The results of SV ratings and Reserve Factors can be used in the management of abnormal vehicle movements as described in Section 8.
- 7.8.3 *BD 86* [7] also provides guidance for converting existing HB ratings to equivalent SV ratings to aid correlation of such ratings with the effects of real vehicles. However, this is necessarily conservative and reassessment to *BD 86* should be considered for critical bridges as described in paragraph 7.6.6.
- 7.8.4 For Special Order movements (greater than 150 tonne) and, in some special cases, for General Order movements, detailed assessments may be required for particular structures where no alternative route is readily available.
- 7.8.5 In such cases, for bridges, consideration may be given to limiting Dynamic Amplification Factors and the effects of normal traffic, which might be on a bridge at the same time as the abnormal load. Guidance for such assessments is provided in Annex D of *BD 86* [7].

7.9 RECOMMENDATIONS

- 7.9.1 The recommendations for assessment of highway structures are:
1. A regime of structural reviews should be implemented whereby the adequacy of structures to carry the specified loads is ascertained when there are significant changes to usage, loading, condition or the assessment standards. A structural review should identify structures which need a full assessment.
 2. A prioritised programme of structural review should be put in place to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards. Where a requirement for assessment is identified, such assessments should be carried out in accordance with national standards which are current at the time.
- 7.9.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Complete the already defined national programme for 40 tonne assessment loading and take appropriate actions arising from the assessments including any interim measures. • Check that assessments results are properly recorded and kept up-to-date (Section 7.6).
TWO	<ul style="list-style-type: none"> • Implement a regime of structural reviews and reassessments as defined in the Code (Section 7.4). • Put in place a prioritised programme of structural reviews to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards (Section 7.4). • Store the assessment results in a Bridge Management System (Section 7.6).
THREE	<ul style="list-style-type: none"> • Utilise assessment results in the planning and management of future maintenance programmes.

7.10 REFERENCES FOR SECTION 7

1. *BD 21 The Assessment of Highway Bridges and Structures*, DMRB 3.4.3, TSO.
2. *BE1/73 Technical Memorandum (Bridges) BE 1/73 Reinforced Concrete for Highway Structures – Superseded Standard*.
3. *BS 5400; Steel, Concrete and Composite Bridge*, British Standards Institution, 1988.
4. *BD 37 Loads for Highway Bridges*, DMRB 1.3.14, TSO.
5. *BD 2 Technical Approval of Highway Structures*, DMRB 1.1.1 TSO.
6. *BA 79 The Management of Sub-standard Highway Structures*, DMRB 3.4.18, TSO.
7. *BD 86 The Assessment of Highway Bridges and Structures for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles*, DMRB 3.4.19, TSO.

Section 8

Management of Abnormal Loads

This section gives recommendations for the management of abnormal indivisible loads on highways. Key features of alternative systems that could be used for assessing the suitability of notified vehicles for crossing the structures on the proposed route are summarised. Guidance is also given on the approach to be used for managing Special Order vehicle movements.

8.1 PURPOSE

- 8.1.1 The movement of abnormal loads on highways needs to be carefully managed so that large and heavy vehicles only use those parts of the road network that can safely accommodate them.



- 8.1.2 In this context an abnormal load is considered to be a vehicle that is outside the classification of normal permitted traffic by virtue of its gross weight, length, width or axle configuration according to current road vehicle regulations.

8.2 RESPONSIBLE PARTIES

- 8.2.1 The management of abnormal loads requires coordination between three particular roles defined as below. These roles are normally carried out by three different people, however in a smaller highway authority these may be performed by the same person.
1. **Abnormal Loads Officer** – the person responsible, within the Authority, for receiving notifications of movements from hauliers, ensuring that such notifications are assessed and that the haulier is advised if there is any reason why a proposed movement should not take place.
 2. **Structures Advisor** – a chartered civil or structural engineer within the bridge management organisation, to whom the Abnormal Loads Officer should refer decisions relating to vehicle movements which fall outside the agreed guidelines which otherwise determine whether or not particular vehicle movements should be accepted.

3. **Road Space Coordinator** – the person responsible within the relevant highway authority for the coordination of all traffic management on the highway network. This responsibility usually includes all planned highway work, including the booking of road space for utility companies and other external parties. Where appropriate this role may be performed by the Traffic Manager (see Section 2.13).

8.3 REQUIREMENTS

- 8.3.1 All owners or managers of highway structures should establish and maintain a system to receive notifications from hauliers in respect of abnormal load movements. The system should enable hauliers to be advised within the statutory time limits if there is any reason why the movement should not proceed.
- 8.3.2 The system should clearly identify the Abnormal Loads Officer, for responding to movement notifications and the circumstances under which they should seek the authority of the Structures Adviser, to determine the appropriate response. In some cases, advice should also be sought from the Road Space Coordinator on special traffic management or other physical restrictions that may be in place along the route. Depending on the size of the structures stock and the level of abnormal vehicle movements, one or more of these roles may be performed by the same person.
- 8.3.3 The suitability of a specific abnormal load to cross a particular structure (if not already known) should be checked broadly in accordance with the procedures recommended in Annex D of *BD86 The Assessment of Highway Bridges and Structures for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles* [1].

8.4 BASIS AND PRINCIPLES

- 8.4.1 The movement of abnormal loads should be managed in such a way as to ensure that the load effects induced by the abnormal loads do not exceed the load bearing capacity of structures on the route.
- 8.4.2 Additionally, the suitability of the abnormal load to travel along the proposed route should be checked by the haulier in relation to any height restrictions from overbridges and restrictions on manoeuvrability along narrow roads and sharp bends etc. The highway and bridge authorities should also warn the haulier if they are aware, from the information received, that there could be potential problems.
- 8.4.3 In certain cases, e.g. vehicles wider than the traffic lane, abnormal loads should be escorted to provide appropriate warning to other traffic. This may not strictly be a bridge management issue, but the Abnormal Loads Officer should ensure that this information reaches the relevant Road Space Coordinator. Escorting may be undertaken by the police or by the haulier concerned as allowed for in the *Code of Practice – Self Escorting of Abnormal Loads and Abnormal Vehicles* [2].
- 8.4.4 Where an initial assessment shows that the load effects induced by an abnormal load marginally exceed the capacity of a bridge on the route, it may be possible for the abnormal load to safely cross the bridge provided the speed of the vehicle is restricted and other normal traffic is kept clear of the

bridge when the abnormal load crosses it. Checks for such situations can be made in accordance with the procedures given in Annex D of BD 86 [1].

- 8.4.5 To process the notifications efficiently and effectively, where large numbers of General Order abnormal load notifications are received each day, it may be appropriate to appoint as an Abnormal Loads Officer a person who can who can perform initial screening of vehicle notifications using information on vehicle height, gross weight and/or axle weights. Where a decision is difficult, the notification should be referred to the Structures Adviser.
- 8.4.6 The highway authority or manager of a stock of structures may employ either a simple manual process or an automated system to process abnormal load notifications, depending on the number of notifications received each day.

8.5 RECOMMENDED REGIME FOR MANAGING ABNORMAL LOADS

General Order Vehicles

- 8.5.1 Regulatory limits on gross weight, axle weight and axle configurations of various categories of abnormal loads and their notification requirements are summarised in Appendix N.
- 8.5.2 As a minimum, records in the form of registers of haulier insurance indemnities and vehicle movement notifications should be maintained.
- 8.5.3 In respect of each notification, the following information should be advised to and retained by the Authority:
1. Date notification received.
 2. Name of haulier.
 3. Date of planned movement.
 4. Expiry date of relevant indemnity (which may be valid for a full year or for a specific movement).
 5. Key features of route.
 6. Gross weight of vehicle.
 7. Axle weights and spacings.
 8. Width of vehicle.
 9. Length of vehicle.
 10. Height of vehicle.
 11. Either acceptance of notification or date of response and reasons given for rejection.
- 8.5.4 A classification system should be established with respect to appropriate ranges of weights, widths and lengths to aid the basic decision making process as to whether a movement notification can be accepted, or if there is an inadequacy along the route of which the haulier should be advised.

8.5.5 The complexity of an appropriate system for a particular road network may vary between the elementary and advanced systems outlined in Section 8.6 below. Therefore, the system should be reviewed regularly to ensure that it remains appropriate. The following should be considered:

1. The strategic importance of the highway route(s) which cross the bridges concerned.
2. The known capacities of the bridges and the deterioration/damage found through inspection/testing.
3. The number and size of abnormal loads which regularly use the route(s).
4. Instances of traffic disruption or accidents caused by the movement of certain types of abnormal loads.

8.5.6 It should be noted that there is no obligation on hauliers to notify the bridge authority of high vehicles where their gross weight, length, width and axle weight comply with the regulations.

Special Order Vehicles

8.5.7 Special Order vehicles are those which exceed any of the regulatory weight and dimension limits for General Order vehicles, see Appendix N.

8.5.8 Special Order and VR1 (specific General Order type vehicle) loads require written permission from the Highways Agency (acting on behalf of the Secretary of State) for movements in England, Scotland and Wales or the equivalent governing body in Northern Ireland, hereafter referred to as the relevant controlling body.

8.5.9 Apart from meeting the above requirement, Special Order vehicles should be managed in a similar manner to General Order vehicles except that agreements relating to the movement should be in place before the Order is issued. There are no statutory time limits for Authorities to respond to Special Order vehicle notifications. However, written responses should normally be sent to the relevant controlling body within 5 to 10 days. Where this is not practicable, the relevant controlling body should be advised accordingly.

8.6 PROCESS FOR MANAGING ABNORMAL LOADS

8.6.1 The process of managing abnormal loads normally uses either an Elementary System or an Advanced System. A system called ESDAL is being developed for the centralised processing of abnormal load movements in the UK. The key features of these systems are summarised below:

Key features of an Elementary System

8.6.2 Notifications are generally received by letter or fax.

8.6.3 Upon receipt, the Abnormal Loads Officer should check that the route of the notified movement actually includes sections of the route(s) for which the authority is responsible. Relevant movements should then be entered onto an abnormal loads register (ideally electronic). The absolute minimum requirement would be to keep the annotated original notification, but an electronic register is strongly recommended.

- 8.6.4 The Abnormal Loads Officer should check whether the haulier has provided a current indemnity. If the haulier has not provided an indemnity, the Abnormal Loads Officer should contact the haulier to request the indemnity. If a copy of the indemnity is not faxed by return, a faxed notification refusal should be sent.
- 8.6.5 The Abnormal Loads Officer should refer to a procedural guidance schedule to check that the load details above certain thresholds are notified to others as appropriate. An example of a procedural guidance schedule is shown in Table 8.1 and this can be customised to an individual authority's requirements.

Table 8.1 - Example of a Procedural Guidance Schedule for Abnormal Loads Officer				
	From	To	Class	Action
Width	0	3.0 m		
	3.0 m	5.0 m	WdA	
	5.0 m	6.1m	WdB	* Notify Road Space Co-ordinator
	6.1 m		WdC	Notify Road Space Co-ordinator
Length	0	18.75 m		
	18.75 m	30.0 m	LgA	
	30.0 m		LgB	Notify Road Space Co-ordinator
Weight	44 t	80 t	WtA	
	80 t	150 t	WtB	Notify Structures Advisor of loads at or exceeding [100 t]
	150 t		WtC	Notify Road Space Co-ordinator and Structures Advisor
Axle	0	[20 t]		
	[20 t]			Notify Road Space Co-ordinator and Structures Advisor
Height	0	5.03 m		
	5.03 m	[6.25] m		* Notify Road Space Co-ordinator and Structures Advisor

Notes for Table 8.1

1. Figures shown in square brackets [] should be defined for the relevant routes.
2. WdA, WdB, WdC, LgA, LgB, WtA, WtB, WtC are recommended classifications.
3. Other figures shown represent limiting dimensions within the rules governing General Order Vehicles (see Appendix N).
4. * These width and height limits will only be notified to the relevant authority for notifications primarily made in respect of weight limits.
5. The actual vehicle widths to be reported to the Road Space Co-ordinator should again be defined for the relevant routes.

- 8.6.6 If the load details do not require referral to other staff, the Abnormal Loads Officer will process the movement directly. Each movement is ticked on the register and/or annotated on the original notification, and the notification is initialled, dated and filed on a discrete file in date order.
- 8.6.7 If the notification is referred to the nominated Structures Advisor for review, the Structures Advisor will check the notification and determine whether the route is acceptable for the load. If so, the Structures Advisor will notify the Abnormal Loads Officer and provide a written record of the decision. The Abnormal Loads Officer will then initial, date and file the notification.
- 8.6.8 If the route is inadequate, the Structures Advisor will confirm this to the Abnormal Loads Officer who will contact the haulier by telephone to advise of the inadequacy and confirm by issue of a fax. The notification will then be marked 'rejected', and initialled, dated and filed.
- 8.6.9 In making their decision, the Structures Advisor should make use of any available database defining capacities of individual structures and of records and knowledge of historic information of similar vehicle movements.
- 8.6.10 For General Order Vehicles, a detailed assessment of individual structures is seldom required.

Key Features of an Advanced System

- 8.6.11 An Advanced System employs a semi-automated comparison between the structural effects of the notified load(s) and the design or the assessed capacity of the structure.
- 8.6.12 An Advanced System may use lane influence lines, either based on typical spans or on critical influence lines obtained for specific structures at assessment.
- 8.6.13 Such an Advanced System requires a significant amount of data defining the locations of individual structures on specific routes together with their structural load bearing capacities.
- 8.6.14 An Advanced System also requires additional processing effort due to the time required to define the detailed axle configuration of notified vehicles. Consequently, such a system benefits from an initial screening process to determine which vehicles should be processed through the full system.
- 8.6.15 An Advanced System is therefore relatively expensive to implement and is only likely to be appropriate for areas that include major routes with a significant number of abnormal load movements each year.
- 8.6.16 However, an Advanced System can significantly reduce the number of notifications that have to be referred to the Structural Advisor.

The ESDAL System

- 8.6.17 ESDAL or the Electronic Service Delivery for Abnormal Loads is a national system being developed by the Highways Agency. When fully implemented, it should include many of the features of an Advanced System as described above.

- 8.6.18 ESDAL is intended to centralise future abnormal load vehicle notifications and provide some initial screening of route to assist hauliers in route planning. ESDAL will undertake four principal tasks:
1. Offer a central database of structure owners and areas and contact details.
 2. Afford electronic global faxing facility.
 3. Identify structures along a proposed route.
 4. Screen routes and optionally undertake Indicative Capacity Appraisals.
- 8.6.19 Bridge owners will be able to engage at whatever level they choose, but full coverage will be essential for items 1 and 2 above.
- 8.6.20 ESDAL is expected to incorporate a facility to provide Indicative Capacity Appraisal for each structure along the proposed movement route, using the information provided by the owner/manager of the structure and the vehicle details provided by the haulier. When it is fully operational, ESDAL could provide the initial screening of vehicles referred to in paragraph 8.4.5. However, ESDAL will not remove the responsibility from the owner/manager of the structure for establishing whether or not a proposed abnormal load should be able to safely cross it, and if not, that an appropriate warning is issued to the haulier.
- 8.6.21 A number of different methods of appraisal will be available. The owner/manager of the structure will be able to choose whether or not to enable the system to perform Indicative Capacity Appraisal and the methodology to be used. Depending on the option chosen, the data to be supplied by the owner/manager about each structure to ESDAL will vary. Further information on ESDAL is available on the web at www.esdal.co.uk.
- 8.6.22 Notifications will still end up, as now, with the owner/manager, but with or without intelligent comment about impact on structures as appropriate.

Approach for dealing with Special Order Vehicles

- 8.6.23 Details of the provisional routes are received from the relevant controlling body.
- 8.6.24 The Abnormal Loads Officer should consult the Road Space Coordinator regarding whether the proposed route has any dimensional restrictions, including those due to any road or street works planned on the movement date which will restrict the movement of the load.
- 8.6.25 Where appropriate, the details should be passed to the Structures Advisor as detailed above, who should check the structural adequacy of the route. If the route is adequate, the Structures Advisor should provide a written record of the decision to the Abnormal Loads Officer, who should initial and date the route and confirm to the relevant controlling body that the route is acceptable.
- 8.6.26 If the route is inadequate the Structures Advisor should contact the Abnormal Loads Officer who advises the relevant controlling body accordingly. The Abnormal Loads Officer should then record the details of the application. The promoter of such a move would then have the option of paying for a more detailed assessment and/or strengthening.

8.7 RECOMMENDATIONS

- 8.7.1 It is recommended that all owners or managers of highway structures should establish and maintain a system to receive notifications from hauliers in respect of General Order abnormal load movements. The system should enable hauliers to be advised within the statutory time limits if there is any reason why the movement should not proceed. The system should also be able to manage the movement of Special Order vehicles in accordance with national standards and regulations.
- 8.7.2 Specific actions to be taken by authorities in meeting the above recommendation are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Establish the roles of Abnormal Loads Officer, Structures Adviser, and Road Space Coordinator as specified in the Code (Section 8.2). • Establish procedures to check the suitability of a specific abnormal load to cross a particular structure broadly in accordance with the procedures given in Annex D of BD86 (Sections 8.5 and 8.6). • Establish an Elementary System for the management of abnormal loads (Section 8.6).
TWO	<ul style="list-style-type: none"> • Establish how and to what extent the Authority will use the ESDAL system, when available, in particular the facility for Indicative Capacity Appraisals. Accordingly make the necessary data available to the ESDAL System (Section 8.6).
THREE	<ul style="list-style-type: none"> • Establish an Advanced System for the management of abnormal loads as appropriate to work alongside the ESDAL System (Section 8.6). • Ensure that the necessary data, including assessment results, are implemented and kept up-to-date within a Bridge Management System and used in the management of abnormal load movements (Section 8.5). • Establish and monitor communication links between the Bridge Management System and the ESDAL System as necessary (Section 8.6).

8.8 REFERENCES FOR SECTION 8

1. *BD 86 The Assessment of Highway Bridges and Structures for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles*, DMRB 3.4.19, TSO.
2. *Code of Practice – Self Escorting of Abnormal Loads and Abnormal Vehicles*, Highways Agency.

Section 9

Asset Information Management

This section provides guidance on the management of asset data and information. A formalised process for information management is described and the data and information needed to support full implementation of the Code is outlined.

9.1 PURPOSE

- 9.1.1 The purpose of **data and information** is to support the management of highway structures, e.g. inspection scheduling, maintenance planning, structural reviews and assessments.



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- 9.1.2 The purpose of **information management** is to provide a formalised procedure for reviewing current data, identifying data needs, determining gaps, capturing data to close the gaps and on-going review and management. The information management process should provide data that is accurate and up-to-date.

9.2 REQUIREMENTS

- 9.2.1 A formalised information management process should be implemented that assists the review of current data, identification of needs and determination of gaps. The identified data and information needs should align with the Good Management Practice recommended in the Code and a prioritised programme should be put in place to close the gaps.
- 9.2.2 The information management process should include an on-going review process to check that the data and information is current, accurate and sufficient.
- 9.2.3 Data and information should be commensurate with that required to support decision-making at network, stock, route, group, individual structure and component level.

9.3 BASIS AND PRINCIPLES

- 9.3.1 Data and information should support the management processes for highway structures. It should be recorded and stored in a format that is cost effective and reliable and that enables it to be readily captured, transferred, accessed and used.

- 9.3.2 Data capture requires considerable resources and should only be undertaken when there is a clear need. A formalised approach should be established for reviewing current data, identifying needs and prioritising capture. The identification of needs should include a formal challenge and an assessment of the benefits they provide.
- 9.3.3 An on-going management and review process should be used to check that the data and information is current, accurate and sufficient. This should identify forthcoming requirements for which a data capture programme should be put in place.

9.4 DEFINITIONS

- 9.4.1 It is helpful to bear in mind the distinction between data, information and knowledge. These terms, in the context of this Code, are defined as follows:
1. **Data** – numbers, words, symbols, pictures, etc. without context or meaning, i.e. data in a raw format.
 2. **Information** – a collection of numbers, words, symbols, pictures, etc. that have meaning, i.e. information is data with context.
 3. **Knowledge** – the understanding of information through assessment, analysis, etc., that provides a basis for decisions to be made.

9.5 INFORMATION MANAGEMENT PROCESS

- 9.5.1 A formalised information management process that supports implementation of the Code and on-going review and management should be adopted. Figure 9.1 shows a generic information management process. Authorities should adopt such a process and develop it according to their particular requirements.

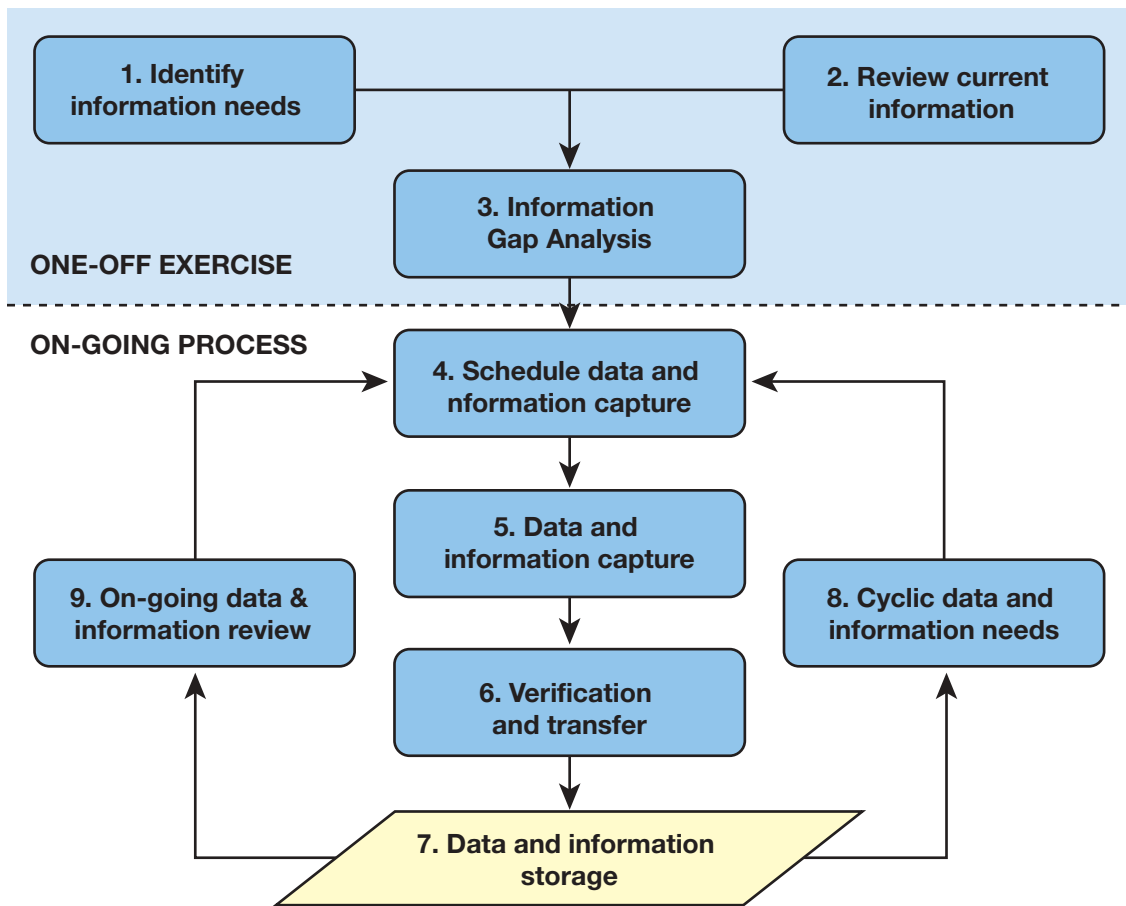


Figure 9.1: Information Management Process

9.5.2 Components 1 to 3 of Figure 9.1 represent the activities that should be undertaken on implementation of the Code in order to identify and analyse the gaps between current (As-Is) and required (To-Be) data and information. Components 4 to 9 represent the on-going data collection and information management cycle that should be implemented. Each of the components is discussed in the following, but for components 1 to 3 also refer to the complementary guidance on As-Is, To-Be and gap analysis provided in Section 11 (*Implementation of the Code*).

1. Identify Information Needs

9.5.3 This activity should identify the data and information required to support the Good Management Practice identified in the Code. It should be carried out before the review of current practice because it establishes the data/information that current practice should be assessed against.

9.5.4 The data and information should be commensurate with the size and characteristics of the highway structures stock and, where appropriate, the manner in which the Good Management Practice will be used. Section 11.6 (*Identify Good Management Practice*) summarises the recommendations and actions that support Good Management Practice and these should be examined to identify the associated data and information needs. Suggested data and information that supports Good Management Practice are presented in Section 9.6.

- 9.5.5 Data and information needs should be challenged during identification. As a minimum the following questions should be considered when identifying data/information needs:
1. What type of data/information is required? For example, inventory, condition and performance.
 2. Why is the data/information required? For example, for structure identification, maintenance planning and/or structural assessment.
 3. Is the data/information essential or desirable for highway structures management?
- 9.5.6 Identification of data and information needs should take a long term view and should not be constrained by resource, funding and system limitations that may need to be overcome to achieve Good Management Practice. Constraints are assessed through the gap analysis, which also includes a more formal assessment of needs.

2. Review Current Information

- 9.5.7 The purpose of this activity is to establish the current status of data and information. Their current status should be assessed against the needs identified under the previous activity using the technique described in Section 11.7 (*Determine Current Practice*). Other criteria to consider in the review, that will assist the subsequent gap analysis, include, but are not restricted to:
1. **Accuracy and completeness** - judgements should be made regarding the accuracy and completeness of the data/information held, e.g. inventory assessed to be 80 % complete.
 2. **Usage** - determine what the data/information is currently used for, e.g. which management process or processes does it support.
 3. **Storage media** - establish the data/information storage media and details of the format, e.g. paper (unbound sheets, formal reports, etc), computerised (bespoke, commercial, simple, advanced), microfiche, video.
 4. **Storage location** - identify the data/information storage location including backup, e.g. shelves, store rooms, archive, local drives, shared servers.
 5. **Processes** - identify the processes currently in place for data/information capture, verification, transfer, retrieval, backup, etc. and the staff responsible for each.
- 9.5.8 The review should be undertaken by or on behalf of the bridge manager. The views of all staff that use highway structures data and information on a regular basis should be sought and included in the review, either through questionnaires, one-to-one interviews or workshops.

3. Information Gap Analysis

- 9.5.9 A gap analysis compares the current (As-Is) position with the required (To-Be) position. The objective of the comparison is to identify and assess where there are gaps in data and information and then prioritise and plan the work to close the gaps.

- 9.5.10 The data and information gap analysis should follow the general procedure described in Section 11.8 (*Gap Analysis*). The gap analysis should seek to establish:
1. Current data and information gaps.
 2. An estimation of the cost of closing the gaps and maintaining the data, e.g. data capture, storage, supporting systems (functionality), resources and training.
 3. The benefits provided by closing the gaps, e.g. how does the information improve structures management and/or support progress towards Good Management Practice.
 4. A prioritised list of actions for closing the data and information gaps. This should take into account any internal and/or external factors/agendas that influence the need for specific data and information, including the recommendations, actions and milestones described in Section 11.6.
- 9.5.11 Further guidance on performing a gap analysis can be found in the *Framework for Highway Asset Management* [1].

4. Schedule Data and Information Capture

- 9.5.12 The output from the gap analysis should be a prioritised list of actions to close the data and information gaps. The list should be developed into a balanced programme that takes account of resource availability and other work requirements. It may be developed as a stand alone plan or be incorporated into the Implementation Plan described in Section 11.9 (*Implementation Plan*).
- 9.5.13 Condition data, captured through General and Principal Inspections, is likely to form a considerable proportion of data requirements. Where appropriate, General and Principal Inspections should be used to compile other information, e.g. location, dimensions, obstacle crossed and material types. Authorities may find this approach convenient and cost effective especially if they are willing/able to wait two to six years for the data, i.e. the General and Principal Inspection cycles. Where this is not acceptable, authorities should undertake a one-off data collection exercise, e.g. to establish an inventory record of all highway structures on the network.

5. Data and Information Capture

- 9.5.14 Data and information capture should be carried out by appropriately qualified, trained and experienced staff. Current techniques of data capture should be reviewed to determine whether they are adequate. Where found to be insufficient, improved or new techniques should be identified and introduced.
- 9.5.15 The approaches, techniques and tools used should be commensurate with the quantity and accuracy of data/information required, for example:
1. The approaches used may be desk study, preliminary desk study followed by site visit, site reconnaissance followed by a more detailed site investigation, etc.

2. The techniques used to record data and information may be pen/paper, data logger, laptop, dictaphone, digital camera, video camera etc., or any combination of these. Predefined data capture sheets/pro forma may be beneficial to assist and direct data/information capture.
 3. The tools used to assist data and information capture may include tape measures, binoculars, access equipment, testing equipment etc.
- 9.5.16 The data and information should be captured and recorded in a consistent way that is compatible with the storage system. Section 6.5 (Inspection Process) describes a good example of the process of data capture.

6. Verification and Transfer

- 9.5.17 Data and information should be verified before storage. Verification may be comprehensive or carried out on a sample. The former approach should be adopted for General Inspection data where the engineer reviews and signs off the pro forma, while the latter may be suitable for reviewing inventory data prior to transfer, e.g. from paper records to computerised format.
- 9.5.18 Data and information verification may, where appropriate, be part of the transfer process, i.e. transfer of data/information captured on site into the central paper-based system or central electronic system (Bridge Management System). Transfer may be manual or automated, for example:
1. **Manual data entry** – transfer from a paper pro forma completed on site into a paper or electronic system in the office.
 2. **Automated data entry** – the data is entered directly into an electronic format on site, e.g. data logger, laptop, hand held devices. The data is then transferred into the central electronic system (Bridge Management System). The transfer may be done remotely or in the office.
- 9.5.19 In all instances of data and information transfer, the staff should be made fully aware of the importance of the task and receive training where appropriate. Checks should be established, in addition to the aforementioned data and information verification, to assess the accuracy of any transfer.

7. Data and Information Storage

- 9.5.20 The majority of data and information on highway structures is stored in paper or electronic records, although some authorities may have microfilm or microfiche records. Authorities should establish a storage system that complies with their procedures, that is appropriate to the size and characteristics of their highway structures stock and that supports the Good Management Practice set down in the Code.

Paper-based Systems

- 9.5.21 In some instances a paper-based system may be appropriate, e.g. where a small number of structures are being managed. Where a paper-based system is used, it is important to consider how the data is manipulated. This type of system is really only convenient for individual structures. Where it is necessary to manipulate data for a whole stock of highway structures, it may prove to be tedious and time-consuming. Currently used paper based systems may be retained provided they are sufficient to facilitate the required management

functions at both structure and stock level. The long term aim should be to transfer the data to an electronic system.

- 9.5.22 If a paper based system is used then a paper record of the Health and Safety File should be held. Authorities may wish to retain hard copies of signed inspection pro forma for legal reasons. The Structure File (Section 9.7) should form the basis of a paper-based system.

Electronic Systems

- 9.5.23 Electronic systems provide the most efficient method of storing, accessing, manipulating and transferring the large amount of data and information generated and required for the management of highway structures. The speed and capacity of modern computer systems make it possible to store large volumes of data and information, including drawings and photographs, and make it easily accessible over a network of users. Many commercial Bridge Management Systems (BMS) have been developed, but it is beyond the scope of the Code to recommend a particular system. Selection of an appropriate system should be made on the basis of particular requirements and the guidance provided in Section 10 (*Framework for a BMS*).
- 9.5.24 Rapid improvements in computer technology and frequent changes to software are a reality today and, before adopting new hardware or software, care should be taken to ensure adequate backward compatibility with older versions to support data sharing and transfer.
- 9.5.25 The benefits of adopting a common electronic format for data and information storage by all authorities include:
1. Easing the sharing of good practice, e.g. lifecycle plans.
 2. Improving the efficiency and effectiveness of data transfer when the responsibility for a highway structure is transferred.
 3. Facilitating the preparation of national statistics and reporting.
- 9.5.26 These benefits are desirable for authorities and DfT. Guidance for a BMS is presented in Section 10 as a means of improving the commonality of data/information storage. In adopting the guidance in Section 10, authorities and commercial software companies should seek to produce storage formats that enable data/information sharing and transfer and have the flexibility to cope with different and changing local and national requirements.

8. Cyclic Data and Information Needs

- 9.5.27 Some data and information capture should be a continuous cyclical process devised to support management by providing reliable up-to-date information. In particular, the continuous cyclical inspections (General and Principal) provide the base data for maintenance planning and management, asset management planning and structural reviews and assessments.
- 9.5.28 The asset inventory should be updated following new construction and relevant data should be updated when maintenance work is completed.

9. On-going Data and Information Review

- 9.5.29 An on-going review of data and information needs should be implemented to ensure they are current, accurate and sufficient and remain relevant to strategic, tactical and operational management levels, and provide the appropriate basis for achieving and sustaining Good Management Practice. This review should give due consideration to existing or changing local and national agenda and requirements.

9.6 DATA AND INFORMATION CATEGORIES

- 9.6.1 This section presents data and information that support the Good Management Practice recommended by the Code, categorised under the following headings:
1. Essential data
 2. Inventory data
 3. Inspection, condition and performance data
 4. Structural assessment and restrictions data
 5. Maintenance data
 6. Cost data
 7. Other management data.



- 9.6.2 **The data and information suggested in each category is based on a thorough review of the processes and practices recommended by the Code. Nevertheless, the lists provided should not be taken as comprehensive and appropriate to all local needs. Authorities are recommended to review the following lists and where required extend, reduce or amend them for their own use.**
- 9.6.3 The categories described below should be held for all types of highway structures. Fields should be omitted if they are not appropriate to a specific type of highway structure.

Essential Data

- 9.6.4 Essential data are defined here as those data and information that are necessary to enable an authority to fulfil their statutory obligations under the Highways Act 1980 [2] in order to safeguard the travelling public and to protect the authority against legal action relating to sub-standard management. The purpose of this category is to enable authorities to readily check if they currently hold fundamental data and information before progressing with the collection of that described in the following categories. For completeness some of the data and information described in this category are also covered by the subsequent categories.
- 9.6.5 The extent of the essential data held depends on the particular requirements of the authority but it is suggested it includes:
1. **Basic inventory data** - the basic information about each highway structure, including structure name/reference, structural type, location, route carried, obstacle crossed (where relevant) and key dimensions.
 2. **Legal data** – details of contracts, licences, legal agreements, letters, etc. that define who is responsible for management, e.g. authority, other owner, third party, maintaining agent. Refer to Section 2.6 (Legal and Procedural Requirements).
 3. **Condition data** – an up-to-date General Inspection pro forma (no more than three years old) should be held for all structures.
 4. **Structural assessment data** - the assessment rating, details of a planned assessment, or details of why the structure is excluded from the assessment programme.
 5. **Health and Safety File** – a H&S file should be maintained for each highway structure as construction work is carried out, see Section 2.7 (*Health and Safety Requirements*).
- 9.6.6 The data considered essential by particular authorities may depend also on imposed requirements arising from government/corporate policy and targets (current and future, if known) relating to the environment and sustainability, resource accounting and budgeting, Best Value, asset valuation etc.

Inventory Data

- 9.6.7 The inventory should hold the basic data and information on the stock of highway structures in terms of descriptive parameters such as structural type, form, construction material and geometry (dimensions, span, width, skew etc). Attributes held in the inventory should enable management to operate at a number of levels, e.g. stock, groups or individual structures. An asset classification general schema is shown in Figure 9.2 and should be used to sub-divide the highway structures stock.

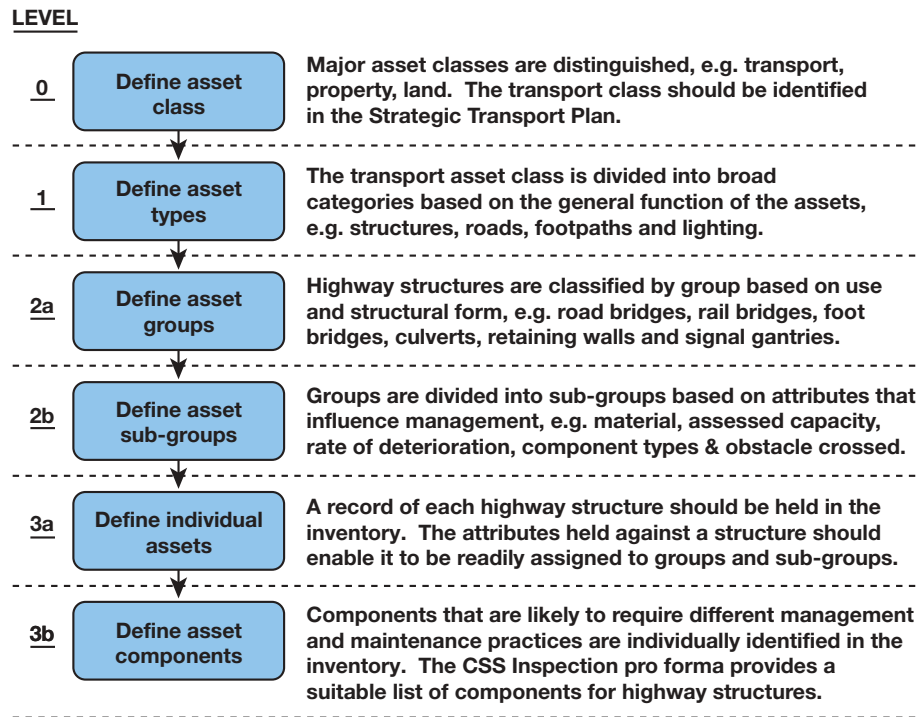


Figure 9.2: Asset classification general schema

9.6.8 An example of how the above classification may be applied to highway bridges is shown in Table 9.1. Authorities should review the classification shown in Table 9.1 and amend and extend as required to meet their management needs.

Asset Type (Level 1)	Group (Level 2a)	Possible sub-group criteria (Level 2b)		
		Structural Form	Primary deck element*	Material type
Structures	Bridges	Arch	Solid spandrel Open spandrel Tied arch	Masonry Concrete
		Slab	Solid slab Voided slab Rib slab	Reinforced concrete Prestressed concrete
		Beam/girder	I or H beams Box beams Girders	Reinforced concrete Prestressed concrete Metal

* Primary Deck Element is the terminology used by the Bridge Condition Indicator [3]; however the Primary Deck Element is referred to as the Main Carrying Element by BRIME [4].

9.6.9 A wide range of groups and sub-groups can be readily established by a Bridge Management System provided the appropriate inventory attributes are held against each structure. For example, an authority may wish to periodically define new groups/sub-groups to determine the potential scale of a particular problem associated with a specific highway structure attribute.

9.6.10 Suggested fields for a highway structures inventory are listed in Table 9.2.

Table 9.2 - Suggested inventory data	
ID	Description
1.1	Structure type, e.g. bridge, culvert, retaining wall.
1.2	Owner and, where appropriate, management, maintenance and inspection responsibilities.
1.3	Structure identifier – reference, name, key number, etc.
1.4	Route carried, e.g. Principal A Road, B Road, footway.
1.5	Structure location, e.g. map reference (easting and northing), GPS, section of road, local position reference.
1.6	Year of construction/reconstruction, designer and design code.
1.7	Location of drawings, photographs, design details, etc.
1.8	Headroom envelopes, minimum headroom, navigation clearance.
1.9	Historic listing or Scheduled Ancient Monument.
1.10	Special access requirements, including details of confined space working, permit to entry or work, maintenance access needs etc.
1.11	Details, including date, of major upgrades and/or modifications, e.g. widening or strengthening.
1.12	Presence of utility services (STATS) – a field indicating ‘Yes’ or ‘No’ may be sufficient rather than specific details.
1.13	External considerations and/or constraints, e.g. social, geographical, environmental, conservation, etc.
1.14	Structure arrangement, e.g. number and location of widenings, number of spans/panels, skew. The following (1.15 to 1.18) should be reported per span/panel and per widening, as appropriate.
1.15	Structural form, e.g. arch, beam and slab.
1.16	General material of construction, e.g. masonry, steel, concrete.
1.17	Obstacle crossed, e.g. road, watercourse, railway.
1.18	Dimensions, e.g. length, width, height.
1.19	List of components, e.g. primary deck element, joints, bearings. The CSS Inspection pro forma provides an appropriate list. The following (1.20 to 1.23) should be reported per component, as appropriate.
1.20	Materials of construction.
1.21	Dimensions.
1.22	Year of construction/installation.
1.23	Manufacturer and unit specifications, e.g. for parapets, bearings and joints.

Inspection, Condition and Performance Data

- 9.6.11 General and Principal Inspections provide the majority of condition data. These inspections should be carried out and recorded as recommended in Section 6 (*Inspection, Testing and Monitoring*). These are supplemented by Special Inspections, testing and monitoring, as appropriate, where the data sought is often focussed on a particular part of the structure or aspect of performance. Such data is often obtained on a “one-off” basis and may include measurements which cannot be conveniently entered into a paper based or electronic system. The database should indicate the location of the full report in such instances.
- 9.6.12 Condition data from previous inspections should be retained as the evolution of this data over time gives a clear indication of the rate of deterioration and residual service life. This data can be used to estimate deterioration rates for different element and structure types which can be used to develop lifecycle plans. Lifecycle plans are discussed in Section 3.7 (*Highway Structures Asset Management Planning*).
- 9.6.13 Condition data should be recorded for each element on the structure. A suggested list of condition and performance data is shown in Table 9.3.

Table 9.3 - Suggested inspection, condition and performance data	
ID	Description
2.1	Date and type of last inspection.
2.2	Date and type of next scheduled inspection.
	Current and historical data and information should be held for items 2.3 to 2.10
2.3	Condition of each inventory component, e.g. severity and extent.
2.4	Priority of the defect as recorded on the inspection pro forma.
2.5	General Inspection pro forma (hard copy or electronic).
2.6	Principal/Special Inspection reports (hard copy or electronic). An electronic system should hold details of the hard copy location if appropriate.
2.7	Testing and monitoring reports and data (hard copy or electronic). An electronic system should hold details of the hard copy location if appropriate.
2.8	Performance Measures and Indicators for individual structures, groups, stock, etc. In particular the Condition, Availability and Reliability Performance Indicators (see Section 3.8).
2.9	Reports of damage during service, e.g. impact, scour, vandalism.
2.10	Performance Targets, e.g. Condition, Availability and Reliability.

Structural Assessment and Restrictions Data

9.6.14 The management of highway structures requires data and information on structural load carrying capacity and any associated restrictions in place. Table 9.4 shows suggested data fields for this category.

Table 9.4 - Suggested assessment and restriction data	
ID	Description
3.1	Original design live loading (HA, HB, abnormal and footway as appropriate).
3.2	Date of last structural review and reason for review.
3.3	Outcome of structural review.
3.4	Date of next structural review.
3.5	Date of last structural assessment and reason for assessment.
3.6	Code/standard/procedure used for assessment (or reason for exclusion from the assessment programme).
3.7	Assessor and checker.
3.8	The vehicle (loading) requirements for the structure, derived from the route requirements, e.g. 40 tonne, abnormal.
3.9	Critical assessment component.
3.10	Assessed capacity and/or live load capacity rating (HA, HB, Abnormal, footway, etc).
3.11	Reserve structural capacity.
3.12	Assessment report (electronic or hard copy and the relevant storage locations).
3.13	Current loading restriction.
3.14	Details of any interim measures currently in place, e.g. physical restrictions, signs, propping, etc.
3.15	Details of most likely diversion route for diverted traffic, e.g. length of diversion, characteristics of diversion area (residential, business, industrial).
3.16	Information to support the recommended regime for managing abnormal loads (see Section 8.5).
3.17	Signed height and width restrictions that are related to physical dimensions of the structure not structural capacity (these should also be linked to item 1.8 in Table 9.1).

Maintenance Data

- 9.6.15 Maintenance data and information should align with asset management planning (Section 3) and maintenance planning and management (Section 5). Table 9.5 provides a list of suggested maintenance data and information. Items 4.1 to 4.5 should be held in the structures workbank (see Section 5.10) and be linked to specific components or structures where appropriate.

Table 9.5 - Suggested maintenance data	
ID	Description
4.1	Description of maintenance need (including classification as described in Section 5.5).
4.2	Maintenance priority score (or a flag to identify work that is non-value managed).
4.3	Proposed/planned date for maintenance.
4.4	Date maintenance carried out.
4.5	Routine maintenance needs – by structure groups or sub-groups.
4.6	Maintenance history.
4.7	Deterioration rates/profiles for different component and material types.
4.8	Service lives (to identify residual life when linked with installation date).
4.9	Lifecycle plans (including maintenance cycles and intervention thresholds) – linked to structure groups or sub-groups.

- 9.6.16 The above data is used in the development of the highway structures component of the Transport Asset Management Plans (Section 3), Forward Work Plans (Section 5) and Annual Work Plans (Section 5).

Cost Data

- 9.6.17 This data category includes unit costs for different types of works. This supports the development and costing of future maintenance works and plans. Suggested cost data is shown in Table 9.6.

Table 9.6 - Suggested cost data	
ID	Description
5.1	Project outturn costs.
5.2	Construction unit rates (also important for asset valuation).
5.3	Maintenance unit rates (routine, preventative and reactive).
5.4	Inspection costs (General, Principal and Special).
5.5	Annual maintenance costs – by maintenance type classification (Section 5.5).
5.6	Testing and monitoring costs.
5.7	Access costs.
5.8	Estimated diversion costs for utility services (STATS).
5.9	Traffic delay costs (estimated).

Other Management Data

- 9.6.18 Other data may also be required for the management of highway structures. Suggested data is shown in Table 9.7.

Table 9.7 - Other suggested management data	
ID	Description
6.1	Technical Approval records, including departures from standards.
6.2	Areas served by structure, e.g. residential, business, industrial.
6.3	Future demand or life requirements.
6.4	Staff details, e.g. training records, qualifications, experience (although it may be more appropriate to hold this information in a corporate HR system).
6.5	Legal data, e.g. details of contracts, licences, legal agreements, and letters that influence management.
6.6	Gross and depreciated asset values – for individual structures and the stock.

- 9.6.19 Authorities should seek to identify other data they require for the management of highway structures that is not included in Tables 9.2 to 9.7.

9.7 STRUCTURE FILE

- 9.7.1 The purpose of the Structure File is to hold the data and information considered appropriate for inspection and maintenance management. By examining the Structure File a bridge manager, bridge engineer or inspector should be able to gain a comprehensive understanding of the structure.
- 9.7.2 There should be a Structure File for each structure or group of minor structures of similar design. The Structure File may be electronic and/or paper. It may be appropriate to generate an electronic Structure File as and when required. The Structure File should form the basis of a paper-based management system.
- 9.7.3 Authorities should review the data and information shown in Tables 9.2 to 9.7 and identify the items that should be included in the Structure File.

9.8 RECOMMENDATIONS

- 9.8.1 The recommendations for asset information management are:
1. Information requirements for implementing Good Management Practice should be established and gaps in current information identified. A prioritised programme should be put in place to capture missing information.
 2. Data and information capture, verification, transfer and storage processes and practices should be established and continually reviewed.
- 9.8.2 Specific actions to be taken by authorities in meeting the above recommendations are listed in the table below, separated into the three implementation milestones described in Sections 1 and 11.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • Identify data and information needs (Sections 9.5 and 9.6). • Review current data and information (Section 9.5). • Undertake a gap analysis and schedule data capture (Section 9.5). • Establish data capture, verification, transfer and storage processes and practices (Section 9.5).
TWO	<ul style="list-style-type: none"> • Capture essential data (Section 9.6). • Establish Structure Files (Section 9.7). • Capture remaining data and information (Sections 9.5 and 9.6). • Programme cyclic data and information needs (Section 9.5).
THREE	<ul style="list-style-type: none"> • Implement an on-going data and information review process (Section 9.5).

9.9 REFERENCES FOR SECTION 9

1. *Framework for Highway Asset Management*, County Surveyors Society, April 2004.
2. *Highways Act 1980*, HMSO.
3. *Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting*, County Surveyors Society, April 2002.
4. *Bridge Management in Europe*, BRIME, March 2004.

Section 10

Framework for a Bridge Management System

This section describes a generic framework for a computerised Bridge Management System, including database, functional and system requirements. The framework is intended to assist authorities in the development or procurement of a Bridge Management System.

10.1 PURPOSE

- 10.1.1 The purpose of a computerised Bridge Management System (BMS) is to assist the bridge manager and others in the management of highway structures. The BMS should support the adoption of processes set out in Sections 2 to 9 of this Code and other management functions in an efficient and effective manner.

10.2 REQUIREMENTS

- 10.2.1 A BMS appropriate to the size and characteristics of the highway structures stock and needs of the authority should be implemented to support the Good Management Practice recommended by the Code.



- 10.2.2 The BMS should be a part of, or align with, the overall Asset Management System (AMS) used for the management of all highway assets. Where the BMS is a standalone system, appropriate interfaces to other systems used by the authority should be provided.

10.3 BASIS AND PRINCIPLES

- 10.3.1 The management of highway structures involves planning, decision-making, scheduling and managing various types of work. A BMS should support these processes through good data storage, management and analysis capabilities.

- 10.3.2 A BMS should not impose or constrain the users to a certain way of working; instead it should support the improvement of an authority's working practices. A BMS should provide tangible benefits when compared to a paper based system, in terms of ability to analyse large quantities of data to assist decision making, efficient storage and retrieval of data, and reduction in manual effort through automation.
- 10.3.3 A BMS should not be a "black box". Instead, the business logic and decision making processes used should be transparent to the users and allow sufficient diagnostic information for checking and debugging.
- 10.3.4 A BMS should meet Government requirements for e-working and interoperability of different computer based systems.

10.4 OUTLINE OF THE FRAMEWORK

- 10.4.1 It is recognised that some of the recommendations in the Code cannot be readily implemented without a computerised tool. This section provides a framework for a BMS and the functionality that it should offer. It is not intended to provide a detailed design of a BMS with business logic and dataflow diagrams. It is left for BMS software developers to provide innovative solutions for meeting the requirements set out here. It is expected that software developers would need to work with bridge managers in designing and developing a BMS based on these requirements.
- 10.4.2 Based on an analysis of the processes and information required for the management of highway structures as set out in Sections 2 to 9 of this Code, the core functionality of the BMS needed to support the users is shown schematically in Figure 10.1. The functional requirements are organised into ten areas, called 'functional modules' which are summarised below and expanded further in Sections 10.5 to 10.14. A 'functional module' does not necessarily imply a 'software module' within the BMS; the system could be designed internally in many different ways to provide the required functionality. Requirements for administration of the BMS are given in Section 10.15 while the overall system architecture and interface requirements with other systems are given in Section 10.16. Guidance to authorities on the procurement of a BMS is provided in Section 10.17.

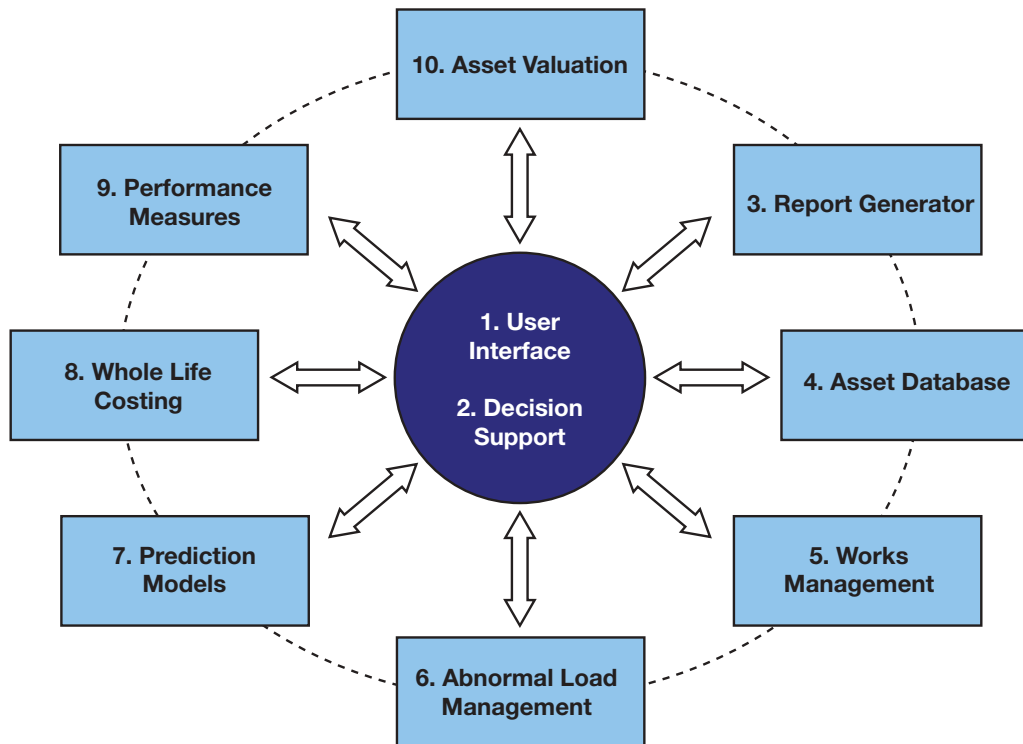


Figure 10.1: Framework for a BMS

10.4.3 The functional modules shown in Figure 10.1 are summarised in the following list.

1. **User Interface** – functionality required by the users of the BMS to interact with the system and access its different functions and information, see Section 10.5.
2. **Decision Support** – functionality needed to interrogate and analyse data and information, carry out what-if analyses to support decision making and short and long term planning, see Section 10.6.
3. **Report Generator** – built in functionality to provide a range of standard reports and ability for the user to define and produce ad hoc reports, see Section 10.7.
4. **Asset Database** – ability to store a wide range of data and information in a logical manner to allow easy entry and retrieval and, where appropriate, transfer to other systems, see Section 10.8.
5. **Works Management** – functionality needed for scheduling the work, issuing work orders and monitoring progress and cost, see Section 10.9.
6. **Abnormal Load Management** – to support the management of abnormal load movements and provide information to the ESDAL system, see Section 10.10.
7. **Prediction Models** – calculations to predict future demand, condition and performance, see Section 10.11.
8. **Whole Life Costing** – ability to calculate and compare Whole Life Costs of alternative maintenance strategies, see Section 10.12.

9. **Performance Measures** – to calculate appropriate national and local Performance Measures, see Section 10.13.
 10. **Asset Valuation** – to support the calculation of the Unit Rates, Gross Replacement and Depreciated Replacement Cost for highway structures, see Section 10.14.
- 10.4.4 Most conventional BMSs provide a comprehensive database and basic scheduling and work management capabilities with associated user interface and report generation functions represented by functional modules 1, 3, 4, and 5. Advanced functionality for planning and decision support, whole life cost appraisal, performance measurement and asset valuation are generally not available. With the publication of the Code it is anticipated that commercial BMS developers will enhance their systems in a phased manner to incorporate the advanced functionality as specified here.

10.5 USER INTERFACE

- 10.5.1 The function of the User Interface is to provide a user friendly environment through which the user can readily access the data, information and all the functionality provided by the BMS.
- 10.5.2 The User Interface should adopt a “windows style” format with a number of logically and intuitively designed folders, screens and dialog boxes to cover the various functions of the BMS. Pull down menus should be used to allow the users to select parameters from a range of pre-defined options which enables sorting and manipulation of the data entered. Free text input should be used only where necessary. The menu items should be readily understandable by the target users; acronyms or codes which are incomprehensible should be avoided.
- 10.5.3 It is desirable to have the User Interface built over a Geographical Information System (GIS), see Section 10.16 for GIS functional requirements.
- 10.5.4 It is important to recognise that the needs of users change with time as new processes or working practices are introduced. It should be possible for the BMS ‘Systems Manager’ to amend the contents of screens and pull down menu lists or create new ones as required without requiring reprogramming by the BMS software developers.
- 10.5.5 The User Interface should allow the user to: enter data through various means, define various types of analyses and queries, display the results and carry out other tasks as necessary. Specific requirements for these functions are specified below.
- 10.5.6 **Manual Data Entry:** There will be a need for the user to enter various types of data manually on to the BMS database, for example defining a new bridge or updating some attributes of an existing bridge. The input should be through suitable screens, dialog boxes, pull-down menu lists or free text entry. Similarly, it should be possible to delete any selected data or a group of data.
- 10.5.7 **Automated Data Entry/Transfer:** The BMS should support the import of data from a range of sources. In particular, when an authority is implementing a new BMS, it should allow the transfer of data from existing systems, databases or excel files. The BMS should also support the download of data from Data Capture Devices and when necessary direct import of data from instrumented

monitoring systems. The User Interface should allow the user to configure the import of data and its transfer to the BMS database in the predefined format. Similarly, it should allow the user to configure and export the data from the BMS to other systems.

- 10.5.8 **Set-up Analyses:** Decision making and maintenance planning tasks involve various types of analyses to be carried out in a predefined sequence. The User Interface should allow the user to set up these analyses through dedicated screens and menu options. Prompts for additional user input should appear at the appropriate stage of the analysis. Where an analysis takes considerable time to execute it should be possible for the user to monitor progress and if necessary abort the analysis.
- 10.5.9 **Display Results:** The User Interface should allow the display of analysis results or database queries on the monitor screen in a user friendly graphical and/or tabular format. It should support saving, exporting and printing of the results displayed.

10.6 DECISION SUPPORT

- 10.6.1 The management of highway structures involves planning and decision making relating to a number of activities and works. It is important that the BMS serves as a useful Decision Support Tool for the bridge manager and other users.
- 10.6.2 The BMS should not be a “black box”; instead the procedures used, the input data and the results should be transparent to the users. The Decision Support functional module should allow the user to formulate and analyse a number of alternatives, carry out what-if analyses and study the impact on results of systematically varying selected input parameters. The results of these analyses should be presented in a readily understandable form to allow the user to make informed choices.
- 10.6.3 The various Decision Support functions can be grouped into those relating to: (i) short term maintenance planning, and (ii) long term asset management planning. The specific BMS functionality required to support these processes are described below. The BMS should be able to apply these functions for an individual structure, a group of structures by route or structure type, and for the structures stock as a whole.

Short Term Maintenance Planning

- 10.6.4 Section 9 (*Asset Information Management*) describes in detail the data and information required for the management of highway structures. The main **inputs** for short term maintenance planning are:
1. Asset inventory data.
 2. Asset condition data based on results of inspection, testing and monitoring.
 3. Results of structural assessment and performance measures.
 4. Unit rates for various types of work on structures.

5. Lifecycle plans and intervention thresholds for different types of maintenance.

10.6.5 The key **outputs** of short term planning are:

1. A prioritised structures workbank.
2. A Forward Work Plan for up to three years.
3. A detailed Annual Plan with start and finish dates for the various schemes or work packages.

10.6.6 The **process** for short term maintenance planning is described in detail in Section 5 and illustrated in Figure 5.1. The functionality that the BMS needs to provide is summarised below.

1. **Identification of Needs** (Section 5.10) - the BMS should compile the maintenance work required on individual elements based on condition and performance data, the work identified from inspections and the intervention thresholds given by the lifecycle plans. The results should then be summarised into a structures workbank which lists the different types of work to be carried out on the affected structures, the likely extent of the works and approximate costs.
2. **Prioritisation and Value Management** (Section 5.11) - the BMS should allow an authority to define and implement the prioritisation criteria they have selected for value management. Once the prioritisation criteria are defined and the associated algorithms implemented into the BMS these should be applied in a consistent manner, although the prioritisation criteria may need to be altered over time due to changing political and corporative objectives and the BMS should support this. The identified needs (from the structures workbank) should be scored and ranked by the BMS using the prioritisation criteria. The system should allow the priorities to be manually amended based on the discussions at the value management workshops.
3. **Scheme Development and Value Engineering** (Section 5.12) - the BMS should allow the user to develop schemes of work by combining the identified needs on individual structures or groups of structures. The BMS should allow value engineering of schemes by providing cost/benefit comparison of alternative options on each structure or alternative ways of packaging work on a group of structures. Opportunities for synergy with other works on the road network should be explored to minimise the overall traffic management and road user delay costs, preferably in conjunction with a Network Management System. Where appropriate the BMS should allow a whole life cost comparison of the considered alternatives. The schemes should be finally ranked taking the costs and benefits into account using the chosen prioritisation criteria.
4. **Forward Work Plan** (Section 5.13) - based on the ranked schemes, the BMS should allow the bridge manager to develop a Forward Work Plan by assigning each scheme to a calendar year while ensuring that the annual budget limits are not exceeded.

5. **Annual Work Plan** (Section 5.14) - the BMS should allow a detailed programming of the schemes identified for the current financial year by assigning start and finish dates for each scheme. Opportunities for synergies with other works on the road network should be considered when scheduling the work.

Long Term Asset Management Planning

10.6.7 The main **inputs** for asset management planning are (see Section 9 for details):

1. Asset inventory data.
2. Asset condition data based on results of inspection, testing and monitoring.
3. Assessment results and performance measures.
4. Unit rates for various types of work on structures.

10.6.8 The **outputs** of asset management planning are:

1. Lifecycle plans and intervention thresholds for various maintenance works.
2. A prioritised long term structures workbank.
3. Long term Work Plan and Financial Plan for highway structures which form the 'structures' input to the authority's Transport Asset Management Plan.

10.6.9 The process for long term asset management planning for highway structures is described in detail in Section 3.7 and illustrated in Figure 3.4. Section 3.7 describes Basic and Advanced AM planning processes for highway structures, it is desirable that the BMS provides functionality to support both of these. The Decision Support functionality that the BMS should provide is summarised below.

1. **Levels of Service and Performance Targets:** The BMS should record the levels of service set for the highway network and specifically how they apply to highway structures. Performance targets should be established as a function of time for the different structure types, groups and sub-groups, and entered into the BMS.
2. **Performance Gap Analysis and Lifecycle Plans:** The BMS should provide basic algorithms for predicting future condition and performance for defined groups of structures, comparison of these against targets and identification of gaps. Lifecycle plans should then be developed to determine optimal maintenance strategies for sustaining the current level of performance, identifying the work needed to enhance performance to the target level, and the work need to sustain the target level of performance over the longer term. Preferably the optimal intervention thresholds for different types of maintenance work should be derived by minimising whole life costs for the generic groups/sub-groups of structures. Where this is not feasible, the BMS should allow the user to manually enter the threshold levels.

3. **Identification of needs:** The BMS functionality should be the same as for short term planning but should operate on a group of structures considering a longer time horizon consistent with the Transport Asset Management Plan.
4. **Value Management:** The BMS functionality should be the same as for short term planning but should operate on a group of structures over the TAMP period.
5. **Work Plan and Financial Plan:** Based on the ranking of the identified work, the BMS should allow the bridge manager to develop a long term Work Plan by assigning each item of work or package of work to a calendar year over the TAMP period. The Work Plan should be developed to provide an even spread of work and costs while satisfying performance requirements. The associated Financial Plan should present the funding requirements to deliver the Work Plan. The BMS should allow rapid assessment, through what-if analyses, of the consequences of allocating less than the optimum level of funding.

10.7 REPORT GENERATOR

- 10.7.1 The BMS should have a comprehensive report generation capability for producing a number of standard reports as well as allowing the user to specify ad-hoc reports. The reports can contain the data and information contained in the BMS database and/or results from different analyses carried out by the user. Wherever possible the information should be presented in a tabular and/or graphical format that is readily understandable. If GIS functionality is available, the results for different structures could be presented over a map base.
- 10.7.2 The user should have an option to save the generated report to a chosen directory on the computer, export the results to other formats (e.g. documents and spreadsheets) and print a hard copy when needed.
- 10.7.3 The Report Generator should be able to generate the following standard reports:
 1. Asset Base – a summary of the entire structures asset base giving number of structures categorised using different criteria such as structure type, road hierarchy, structural form, material of construction, age, span length of bridges, geographical divisions, etc. The results should be presented in the form of histograms, pie charts etc, as appropriate.
 2. Performance Measures – report on the values, trends and breakdown of performance measures by structure type, road hierarchy, construction material etc. presented in the form of histograms, see Section 3.8 for details.
 3. Asset Valuation – report the main asset valuation information including replacement Unit Rates, Gross Replacement Costs, Depreciated Replacement Costs and details of any changes since the last valuation for the overall structures stock as well as for various structure types, groups/subgroups etc, see Section 4.7.
 4. Long term Work Plan and Financial Plan – work packages produced by long term asset management planning showing the work to be carried out on the structures stock broken down by work type, structure type,

road hierarchy and year. The funding requirement should be presented in a similar manner.

5. Forward Work Plan and Annual Plan – the results of short term maintenance planning.

10.7.4 The Report Generator should allow the user to configure and produce a number of ad hoc reports based on the information contained on the asset database. This could include for example:

1. Number and names of structures for which scheduled General and Principal inspections are overdue;
2. Number and names of structures which are substandard, restricted, being monitored, etc.
3. Similarly, HB or SV capacities of structures on a specified route.

10.7.5 The BMS should allow users to save the format created for an ad-hoc report for later use. It should also be possible to amend or delete the saved ad-hoc format.

10.8 ASSET DATABASE

10.8.1 The asset database should enable an authority to record and maintain data and information about the highway structures in a standard format. The asset database should enable each asset to be uniquely identified by its Structure ID (see Table 9.1 in Section 9) and allow a number of attributes to be held against the ID (either assigned by the user when adding an asset or assigned automatically by the BMS when a record is created).

10.8.2 It is very important to use a common location referencing system across all of the highway assets owned by an authority. This allows a common GIS to be used for the entire network and enables information on different assets to be aggregated based on location and readily exchanged between systems.

10.8.3 Where a structure crosses different obstacles, for example a bridge crossing over a road, a mainline railway and an underground line, the location referencing system and the database should be able to record each of the intersections between the structure and the obstacles crossed.

10.8.4 The database should be flexible and readily configurable. As the needs of the authority change over time, it should be possible for the BMS Systems Manager to add new attributes against different element or structure types.

10.8.5 The BMS should be able to reference appropriate attributes by time. This would allow systematic tracking and trending of changes to the asset inventory, condition and performance as well as tracking of inspections, assessments, minor and major maintenance, upgrading, widening or replacement work carried out on structures.

10.8.6 Section 9 (*Asset Information Management*) describes the information management process and the data/information categories required to support the management of highway structures. As a minimum the asset database should enable efficient storage and retrieval of the data/information items described in Section 9.6 (*Data and Information Categories*), and summarised below:

1. Asset inventory – structure ID, location and other general data, geometry, material, construction data, access arrangements etc. It may be necessary to store the inventory data in a series of cross-referenced database tables.
 2. Inspection, condition and performance data – element condition data on the severity, extent and priority of defects recorded during inspections. Also, results of testing and monitoring and performance indicator scores and their target values, etc.
 3. Structural assessment and restrictions data - assessed capacities against different load types, capacity reserve factors, critical members and their condition factors, restrictions on structures, etc.
 4. Maintenance data – maintenance needs and structures workbank, scheme data and maintenance schedules, service lives, lifecycle plans. History of all significant maintenance work carried out on elements should be recorded.
 5. Cost data - project outturn costs, unit rates for construction, replacement and maintenance works, access and traffic management costs, STATS costs, etc.
 6. Other management data – departures from standards, legal requirements, asset values, etc.
- 10.8.7 In addition to the alphanumeric data held in database tables, the BMS should also be able to store electronic files of various records such as structure file, operations and maintenance manuals, digital photographs of structures and individual defects, etc. These should be linked to the Structure ID and accessible through the User Interface.

10.9 WORKS MANAGEMENT

- 10.9.1 The Works Management module should allow the bridge manager and other staff to schedule different types of work, monitor progress and record outputs.
- 10.9.2 Handheld devices based on the Geographical Positioning System (GPS) with internet or wireless links are increasingly being used to communicate with inspection and maintenance staff and manage works. The BMS should support GPS functionality.
- 10.9.3 Specific functionality that should be provided by the Works Management module include:
1. Schedule General and Principal Inspections and monitoring checks as per predefined intervals for specific structure types with a facility for the inspector to manually adjust actual dates when required.
 2. Schedule acceptance inspections, special inspections, and testing when required and as specified by the user.
 3. Schedule structural reviews and assessments as per defined regimes and as specified by the user.

4. Schedule different types of maintenance work as per the Annual Plan and as amended by the user to take account of other works/constraints on the network.
5. Schedule resources, issue work orders and 'permits to work', monitor progress and productivity of staff.
6. Manage or inform staff about access arrangements and other Health & Safety issues relevant to the work on specific structures.
7. Record outputs and compare these against project plans. Allow electronic sign-off of work completion where the authority wishes to use this facility.
8. Record outturn costs and pass these to the authority's finance system.

10.10 ABNORMAL LOAD MANAGEMENT

10.10.1 Trunk road authorities and some local highway authorities have to deal with hundreds of abnormal load movements each day while other local authorities receive only a few notifications over a month. Section 8 (*Management of Abnormal Loads*) recommends authorities to choose and implement either an 'Elementary' or an 'Advanced' system for managing abnormal load movements depending on their needs.

10.10.2 The BMS should support the management of abnormal loads in the following ways:

1. Receive notification sent by the hauliers, log the notice on to the abnormal loads movement database and alert the Abnormal Loads Officer to deal with the notice in a timely manner. Send a fax to the haulier if the movement is to be refused or asking for missing information.
2. Where a GIS facility is available, display the notified route on the authority's road map and identify all the structures on the route and the associated HB or SV ratings and reserve factors. If possible identify any headroom or manoeuvrability restrictions or road works on the proposed route which has an impact on the proposed movement and inform the haulier accordingly.
3. Where an 'Advanced' system is used allow the Abnormal Loads Officer to compare load effects of notified vehicles against design or assessed capacities of each structure on the route according to predefined rules. The system should also enable checks to be made for regulated movement, for example with speed or clearance restrictions.

10.10.3 If the authority decides to use the ESDAL (Electronic Service Delivery of Abnormal Loads) system (Section 8.6) the BMS should be configured to interface with ESDAL based on the level of functionality the authority chooses to adopt. This may include one or more of the following functionalities to be provided by the BMS:

1. Facility to receive notifications and respond to the haulier through ESDAL.
2. Supply the contact details, basic inventory, location, load capacity, headroom and other general data as required by the ESDAL system. Any

special restrictions on the movement of abnormal vehicles should also be flagged up.

3. Data required for Indicative Capacity Appraisals where this option has been chosen. This may include information on number of lanes, structural form, material of construction, span lengths for bridges, influence lines, etc.

10.11 PREDICTION MODELS

10.11.1 In providing decision support for long term asset management planning a number of prediction models are required and the BMS should offer basic analytical capabilities in this regard. The functional requirements for the BMS in predicting future demand, condition, and performance are given below.

10.11.2 The **inputs** required for the prediction models are:

1. Asset inventory with structures appropriately categorised into type, group and sub-groups, and elements grouped by type and construction material.
2. Deterioration profiles for the different element groups giving the relationship between element condition (e.g. Element Condition Index) and time in years to deteriorate to the different condition states. The deterioration profiles should be defined for Severe, Moderate and Mild exposure conditions.
3. Relationships between condition and element capacity, expressed in terms of simple mathematical functions, for the different element types.
4. Mathematical functions describing the variation with time of traffic volume, maximum gross vehicle weight and axle weight.

10.11.3 The key **outputs** required from the prediction models are:

1. Change in element condition and capacity with time.
2. Growth in traffic volume, permitted gross vehicle weight and axle weights with time.
3. Increase in the extent of maintenance work with time.

10.11.4 The **process** for converting the inputs to the required outputs requires simple mathematical operations. It is suggested that detailed technical models for forecasting traffic growth and deterioration are kept outside the BMS; these calculations should be performed using specialist software tools and results input to the BMS in the form defined above.

10.12 WHOLE LIFE COSTING

10.12.1 It is important that the asset management planning takes account of the entire lifecycle of structures and seeks to minimise whole life costs. The development of lifecycle plans and value engineering of schemes require whole life cost comparisons. Guidance for whole life costing is given in Section 5 (*Maintenance Planning and Management*).

10.12.2 The **inputs** required for whole life costing are:

1. Asset inventory with structures appropriately categorised into type, group and sub-groups and elements grouped by type and construction material.
2. Unit rates for various types of maintenance work and associated access, traffic management, STATS diversion costs, etc.
3. The Treasury discount rate.
4. Alternative options for carrying out the work or maintenance strategies for groups of structures with an appropriate breakdown of scope of work on individual structures and elements.

10.12.3 The main **outputs** from whole life costing are:

1. Net Present Value of whole life cost of the specified alternatives.
2. Cost profiles with time (discounted and undiscounted).

10.12.4 The **process** for producing whole life cost profiles is summarised below, see Appendix J for details:

1. Based on the current condition and performance of the concerned structures/elements calculate the change in condition, performance and extent of maintenance work with time using the prediction models discussed in Section 10.11 above.
2. Combining the above with 'intervention thresholds' given by the lifecycle plans, determine the timing and scope of the different types of maintenance work for each of the specified alternatives.
3. Based on the input unit rates, calculate the cost profiles with time for the alternatives. In calculating the whole life costs, the following cost components should be included:
 - a. Direct plant, material, labour and supervision costs including site preliminaries.
 - b. Access and traffic management costs.
 - c. STATS diversion costs and possession costs to railway and waterway authorities, if relevant.
 - d. Road user delay costs arising from disruption during maintenance work and disruption due to restrictions that may have to be imposed on structures due to potential shortfall in performance.
4. Calculate Net Present Value of whole life cost of each alternative by discounting future costs using the Treasury discount rate. If the need for major maintenance/upgrade in the future is uncertain, the associated costs should be factored by the probability of this work being necessary.

10.13 PERFORMANCE MEASURES

- 10.13.1 Performance measures are used to monitor asset health and management effectiveness. These are also used for target setting to achieve the required Levels of Service and for developing long term Transport Asset Management Plans.
- 10.13.2 The BMS should provide functionality for calculating the values of performance measures for individual structures, a group of structures and for the structures stock.
- 10.13.3 Suggested performance measures for highway structures are given in Section 3.8 of the Code. Reference should be made to the Highways Agency & CSS *Guidance Document for Performance Measurement of Highway Structures* [1], which provides detailed procedures and algorithms for the calculation of Condition PI, Reliability PI, Availability PI and the Structures Workbank.

10.14 ASSET VALUATION

- 10.14.1 Asset valuation is a key requirement of Whole of Government Accounts. It provides a monetary value of the highway assets to be included in an authority's Balance Sheet. Asset Valuation also provides a measure of depreciation of highway structures representing the consumption of the assets in delivering services to the public. Asset Value is also used as a key performance measure.
- 10.14.2 Some authorities may choose to develop a standalone system for the valuation of all highway assets. In this case the BMS should be able to transfer the necessary asset inventory, condition, performance, and unit rate information to the Asset Valuation System (AVS). In turn it should import the calculated asset values for individual structures and store these on the asset database.
- 10.14.3 On the other hand, if an authority wishes to value its highway structures assets using the BMS, this functionality should be available.
- 10.14.4 The detailed procedures and algorithms, including the required input data, for asset valuation can be found in *CSS Guidance Document for Highway Infrastructure Asset Valuation* [2].

10.15 SYSTEM ADMINISTRATION

- 10.15.1 The systems administrator managing the BMS needs additional functionality to normal users for managing the system. These are given below.

Administrator Controls

- 10.15.2 The systems administrator should be responsible for the configuration of the system to meet the authority's needs and administer user accounts. Typically, the functionality and user interfaces/commands available to the systems administrator should include:
1. Create/delete user accounts.
 2. Create/delete user account profiles and associate/disassociate account profiles with user accounts.

3. Assign users to defined groups where each group may have specific degrees of control.
4. Associate disk space/processing availability with specific tasks.
5. Monitor user process activity.
6. Provide backup and archive facilities.
7. Override password and user settings.
8. Configure user logs.
9. Manage and monitor system performance and capacity.
10. Restore data.
11. Allow thresholds to be set and appropriate alerts to be defined in advance of capacity or performance issues developing.
12. Configure file storage locations.
13. Provide user or group alerts in the event of an emergency such as critical system maintenance.
14. Stop and restart the system.
15. Stop, restart and delete processes and sub-process relating to the user level, application level and operating system.

User Access Settings

10.15.3 User access settings reflect the role the user has within the organisation and therefore refer to what functionality will be available for each user and/or each user group. User access settings should be based upon a multi-tiered hierarchical system. For each user or group the administrator should be able to allow or restrict command options. This would also apply to screen views and reporting facilities.

10.15.4 Typically, the functionality for user access settings should include:

1. The configuration of user access account types or classes such as permanent or contract.
2. The configuration of user access groups whereby once a group is created the account access facilities are replicated for each member of that group.
3. Allow for anonymous user with restricted access to information.
4. Define some form of geographical or regional scope.

Database Configuration

10.15.5 The database configuration should reflect the core data and information needs of the Code and reflect the probable user community demands.

10.15.6 The database configuration may include:

1. Off-line working (remote working).
2. Logical synchronisation.
3. Database backed web services.
4. Selective client-server applications.

10.15.7 The database configuration should be open and be structured in such a way as to allow logical queries performed externally to the dependent application. The output of a query should be exported to a commonly available file format. The database schema should be available as part of the application.

User Log

10.15.8 Administrators, managers and selective users should be able to make enquiries through the User Interface to determine when certain activities were carried out by users. The system should therefore facilitate configurable user logging. The interface to the user logs should be configurable so that a specific selection of data can be queried or hidden from view depending upon the user account.

10.15.9 User logs should be retained live on the system for up to a 12 month period and archived after that time. User logs or archive data sets should be retrievable and reloaded into the system for query purposes. The archive dataset should be able to be removed without affecting current user log data. User logging should include:

1. Successful username logged in.
2. Time/date logged in.
3. Time/date logged out.
4. Logout flag - user logged out/system logged out user due to user inactivity.
5. Time since last logon.
6. Authorisation activity (e.g. reference code).
7. Time/date authorisation approved.
8. Time/date authorisation rejected.
9. Unsuccessful username login attempt.
10. Time/date attempted login.

Security

10.15.10 User security relates to the provision of system user access and the way in which the provision of access is granted and managed. Where the system is accessible across the internet and digital certificates are required then the system should comply with the latest HMG's (Her Majesty's Government)

Minimum Requirements for the Verification of the Identity of Individuals. The scope of which describes the minimum requirements for the validation and verification of an individual identity as part of the process of issuing a digital certificate or a PIN or Password for use with e-government services.

10.16 SYSTEMS REQUIREMENTS

10.16.1 In addition to the user requirements there are a number of systems requirements that a BMS should satisfy so that it can meet all of the authority's needs and communicate effectively with other systems. These are set out below.

System Architecture

10.16.2 The systems architecture should be configured in such a way as to reflect and optimise the information needs of the BMS. On that basis the database configuration should allow for the management of individual structures, groups of structure types, and the structures stock as a whole.



10.16.3 In addition, the systems architecture should allow for functional components to be integrated as part of the whole system. This may include messaging hubs for a number of communication mediums, partial but managed localised relational databases that are synchronised based upon business rule sets. This will allow effective remote working and optimise the possibilities for on-the-ground use of data.

Compliance with Industry Standards

10.16.4 The BMS should be compliant with existing standards and publicly available policies. Where this is not appropriate then these areas of system design and functionality should be developed through best practice.

10.16.5 Systems development standards are available that allow the development and functionality of the system to be mapped and presented in an unambiguous way. The software design should be able to demonstrate that the system is sustainable not only from a software supplier's perspective but also from a customer perspective. This provides assurances that the BMS is capable of accommodating minor and major technological changes that may occur in the future. This would also apply to the nature of the system architecture.

10.16.6 Compliance, for example, may relate to the whole lifecycle of the BMS from conception through to delivery and long term support. On that basis there are a number of standards and practices that the developer as well as the end user can refer to. This can include but not be limited to:

1. Alignment with the Internet: the universal adoption of common specifications used on the Internet and World Wide Web for all public sector information systems.
2. Adoption of XML as the primary standard for data integration and data management for all public sector systems.
3. Adoption of the browser: all public sector information systems are to be accessible through browser-based technology; other interfaces are permitted but only in addition to browser-based ones.
4. The addition of metadata to government information resources.
5. The development and adoption of the e-Government Meta Data Standard (e-GMS), based on the international Dublin Core model (ISO 15836).
6. The development and maintenance of the GCL.
7. Adherence to the electronic-Government Interoperability Framework (e-GIF) is mandated throughout the public sector.
8. Interfaces between government information systems and intermediaries providing e-Government services should conform to the standards in the e-GIF. Interfaces between intermediaries and the public are outside the scope of the e-GIF.

10.16.7 To provide assurance the developer must show how the relevant standards and protocols have been interpreted and applied. Where a deviation is necessary in order to achieve the required functionality the supplier must document the variances as this may be considered as a risk for future compliance with the standard.

10.16.8 Organisations responsible for developing software must be accredited with the appropriate quality assurance systems. This must include as a minimum BS ISO 9001 & 9002 and Tick-IT.

Compliance with Industry Languages

10.16.9 The system is not necessarily bound to use a specific standard language although the software must be based on a stable language platform. The selection of development language is generally left to the software supplier. However, it is anticipated that authorities will have their own systems architecture that has been developed for strategic and tactical reasons.

10.16.10 Where interfaces are involved, for example to areas of a backend relational database, it is important that the system will be able to use a number of generally available communication protocols. These must not be bespoke otherwise the authority has to solely rely upon a single source supplier.

Operating System

- 10.16.11 The operating system will be generally available and reasonably ubiquitous. The selection of the operating system can be a strategic decision made by the supplier. For example the dependent operating system may be based on Unix, Linux or a Windows environment.

Database System

- 10.16.12 The dependent relational database system should be generally available and ubiquitous and be supported by a range of common hardware platforms including commonly available processing chip sets. The database should be fully scalable and allow seamless interfaces from remote handheld devices through to consolidated or distributed backend systems.

Database Configurability

- 10.16.13 The database schema should be published and made available to the client so that, if necessary, datasets can be used for areas outside the scope of the BMS. The BMS database should therefore be allowed to be updated from an external source. Where necessary additional fields can be configured to provide additional functionality.

GIS

- 10.16.14 The BMS should be capable of interacting with common GIS interfaces and where appropriate data from the database would be made available to be read in conjunction with the GIS software. The system should be capable of utilising a number of GPS standards that may then be interpreted for a number of uses. For example, conversions from GPS coordinates to OS coordinates. This may or may not be stored as part of the relational database systems.

Communication with Other Systems

- 10.16.15 Development and/or implementation of a BMS should give due consideration to the relationships required with other systems. It may be necessary for the BMS to share and/or retrieve data from other systems such as GIS, roads/lighting management systems, Finance System, Human Resources System, etc.
- 10.16.16 Data sharing/transfer can be either networked (or fully integrated if the BMS is one component of a large Asset Management System) or be in the form of manual export/import, e.g. via floppy disks, CDs or data keys. If the systems are networked then data can be readily shared. If the systems are not networked then the required data should be exported/imported on a regular basis and protocols should be established and implemented for removing expired data.

10.17 PROCUREMENT OF A BMS

Procurement Considerations

- 10.17.1 Procuring a BMS is an important business critical decision. The choice of a BMS has longer term impact on an authority's working practices and the efficiency savings that can be made through automation. The following important considerations should be made in the procurement of a BMS.

1. **Functionality.** The BMS should meet most, if not all, of the functional requirements set out in this Section. There should be a clear plan for incorporating functionality that may be missing.
2. **Cost of Ownership.** In procuring a BMS the full cost of ownership and use of the system over a period of up to 20 years should be made. The total cost can be much higher than the initial direct cost of procurement and should include:
 - a. *Direct costs* - in procuring a commercial system these would be the direct licence costs which typically depend on the number of users. In developing a bespoke system the full development costs over a period of time for the final required functionality should be estimated.
 - b. *Initial configuration and data migration costs* - these costs can be very high and should not be underestimated. This would include developing process maps detailing how an authority plans to use the system and configuring the BMS accordingly. The configuration costs depend on system readiness for the intended application and can vary significantly between systems.
 - c. *Resourcing and training costs* - implementing a BMS may require additional resources, for example a systems manager, data quality manager etc. All users of the system would need to be properly trained to derive full benefits of the system. Implementing a BMS often results in some of the existing roles becoming redundant and the costs of retraining/redeployment of concerned staff should also be considered, which may offset the cost savings achieved through automation.
 - d. *Change management costs* - implementing a BMS in a large organisation and migration from the existing practices to a new way of working can often cause considerable disruption in the beginning. Proper change management procedures should be followed to motivate all staff to embrace the new system and make the BMS implementation a success.
 - e. *Maintenance and user support costs* - commercial software vendors provide annual maintenance and user support, the costs for which can be typically 20% of initial licence costs per annum.
 - f. *Software upgrade costs* - in most cases minor improvements to the software are covered by the annual maintenance fee. However, any major enhancements may have to be shared amongst all licence holders of a system.
 - g. *Hardware upgrade costs* – if hardware upgrade is necessitated by the BMS these should be included in the total cost of ownership.
 - h. *Decommissioning and changeover costs* - an authority may need to changeover to a new BMS at some stage in the future for various reasons. The cost of decommissioning the existing system and migration to a new system should also be considered in determining the full cost of ownership of a BMS.

3. **Versatility.** A number of general purpose commercial Asset Management Systems are currently available which can be used for the management of different types of assets. If an authority already has such a system for the management of its road assets, the feasibility of extending this to manage highway structures should be explored before procuring a new BMS. In addition to offering significant cost savings this option would also have the advantages of an integrated system for the management of the highway infrastructure as a whole.
4. **Flexibility.** The chosen system should offer the flexibility for modular procurement allowing authorities to procure the basic system first and then add further modules, for example street works management, customer relationship management, crew scheduling, etc. as and when required.
5. **Platform Independency.** Most BMSs are developed based on a database platform such as Oracle, MS-SQL etc. Similarly, a number of different GIS software packages are available. The market for database and GIS systems is rapidly changing and it is important that the BMS is able to work with a number of different database and GIS systems and not impose specific systems on authorities. This would allow an authority to have a single corporate database and a GIS system which support one or more systems for managing assets.
6. **Configurability.** The needs of an authority inevitably change with time. The BMS should be readily configurable in terms of how an authority chooses to disaggregate its asset inventory and what attributes are stored against each structure or structural element. Once the system is configured to meet the authority's current needs, it should be possible for the systems administrator to make minor additions/amendments in the future without the need for re-programming by the software developer.
7. **User Support, Training and Knowledge Transfer.** It is important to ensure that the BMS supplier has adequate arrangements for user support with agreed levels of service. The availability of good facilities for training of end users and knowledge transfer to an authority's staff responsible for managing the BMS is also an important consideration in the choice of a BMS.
8. **Maintainability.** In order to ensure business continuity it is important to ensure that the BMS supplier can provide adequate maintenance support, with agreed response times for fixing any bugs and system failures.
9. **Sustainability.** The costs of replacing a BMS and migrating to a new system are prohibitive and it is therefore important to ascertain whether a BMS supplier can continually upgrade and improve the system as the needs of users change and new technologies develop. The financial stability, the number of licence holders using a BMS, track record, recent sales trend, and the company's long term strategy should be looked at before choosing a supplier.
10. **Procurement Route.** The options available to authorities for procuring a BMS are listed below and the benefits and drawbacks of each option are discussed further in the following.
 - a. Develop a bespoke system;

- b. Procure a commercial system;
- c. Use a 'hosting facility'.

Develop a Bespoke System

- 10.17.2 This option could involve developing a new BMS from start or enhancing an existing in-house system to meet the functional requirements specified here. The development may be carried out by an in-house software team or an external firm is commissioned to develop the system; the latter is usually the preferred option.
- 10.17.3 Developing a bespoke system can be very expensive and carries considerable risks. It would be difficult to ensure the long term sustainability of the system. This option should not generally be considered unless the authority's requirements are unique and cannot be met by commercial systems.
- 10.17.4 Developing a bespoke system may only be feasible for a large authority with hundreds of users. The Highways Agency, for example, commissioned the development of a bespoke system for use by all its Managing Agents.
- 10.17.5 Alternatively, a number of authorities may join together and commission a software firm to develop a system to meet their specific needs. In this case opportunities for partnering with the software firm with shared IPR and option for selling the system to other authorities should be explored. It is always useful to start with an existing system and enhance it further to meet the requirements. For example, the London Bridges Engineering Group, comprising 33 London Boroughs, along with a number of other local authorities commissioned the development of a commercial BMS.

Procure a Commercial System

- 10.17.6 A number of commercial general purpose Asset Management Systems (AMS) and dedicated Bridge Management Systems are currently available on the market. It is anticipated that the suppliers of these systems will enhance their systems to incorporate the functional requirements specified here over the coming years.
- 10.17.7 If an authority already uses a general purpose AMS for managing its road assets, which is compliant with the UKPMS requirements, it is worth exploring the feasibility and costs/benefits of extending this system to manage highway structures assets. In this case the supplier's plans for meeting the BMS requirements specified here should be ascertained and appropriate assurances secured in this regard.
- 10.17.8 Procuring a dedicated commercial BMS is likely to be feasible only for a large local authority with several thousand structures to manage.
- 10.17.9 Several local authorities, for example members of a CSS regional working group, could explore the option of partnering with a commercial AMS/BMS supplier to fund the enhancement of an existing system to meet the functional requirements specified here. This will expedite the BMS development and allows the authorities to participate in and influence the detailed design and development of the system.

Use a 'Hosting Facility'

- 10.17.10 Procuring and implementing a commercial BMS, with its attendant requirements for maintenance and in-house support, may not be feasible for a smaller authority with only a few hundred structures to manage. In such cases, an authority should explore the option of availing the hosting facility offered by a number of commercial software suppliers.
- 10.17.11 A hosting facility generally involves the software company providing a managed service for loading the authority's data onto the system, keeping the data up-to-date as instructed by the authority, generating reports as requested and also allowing the authority's users to operate the system remotely. In this arrangement the authority does not 'buy' the system; instead it pays a periodic management fee to the supplier.
- 10.17.12 The hosting option insures the authority to some extent against future changes in the software market and technological advances. It gives the authority flexibility to switch to a new system or a hosting facility from a new supplier at any time. It is however important that the authority's data is kept up-to-date, the integrity of the data can be ensured and the current system is able to readily export the data to a new system. This has to be balanced against the costs of training all the users on the new system. For this reason the hosting facility is likely to be feasible where the authority's needs for accessing the system are minimal.

10.18 RECOMMENDATIONS

- 10.18.1 It is recommended that a Bridge Management System appropriate to the size and characteristics of the highway structures stock and needs of the authority should be implemented to support the Good Management Practice set out in this Code.
- 10.18.2 The functional requirements for the BMS specified in this section can be developed in a phased manner consistent with the authority's progress towards the Good Management Practice.
- 10.18.3 Specific BMS functionality to be developed in the three implementation milestones described in Sections 1 and 11 are listed in the table below.

Milestone	Actions
ONE	<ul style="list-style-type: none"> • The BMS should have a database with a listing of all highway structures with basic inventory details recorded for each asset. It would be preferable to store inspection results on the BMS (Section 10.8).
TWO	<ul style="list-style-type: none"> • The BMS should incorporate the following functional modules: <ul style="list-style-type: none"> ◦ User Interface (Section 10.5). ◦ Report Generator (Section 10.7). ◦ Asset Database (Section 10.8). ◦ Works Management (Section 10.9). ◦ Abnormal Load Management (Section 10.10). ◦ Performance Measures (Section 10.13). ◦ Decision Support for short term planning and Basic AM planning (Section 10.6).
THREE	<ul style="list-style-type: none"> • In addition to the above, the BMS should incorporate the following functional modules: <ul style="list-style-type: none"> ◦ Prediction Models (Section 10.11). ◦ Whole Life Costing (Section 10.12). ◦ Asset Valuation (Section 10.14). ◦ Decision Support for Advanced AM planning (Section 10.6).

10.18.4 It is not necessary that the same BMS is developed gradually over the three milestones. The existing in-house system in an authority may be adequate to meet the requirements in Milestone 1; however, this system may not be suitable for further development to incorporate the requirements for Milestone 2. Many of the widely used commercial BMSs in the UK at present should be able to meet the majority of the requirements for Milestone 2; and these systems may be enhanced further to meet the requirements of Milestone 3.

10.19 REFERENCES FOR SECTION 10

1. *Guidance Document for Performance Measurement of Highway Structures, Parts A, B & C*, Highways Agency and County Surveyors Society, Version 1.3, February 2005, www.cssnet.org.uk
2. *Guidance Document for Highway Infrastructure Asset Valuation*, CSS, 2005

Section 11

Implementation of the Code

This section describes a process for implementing the recommendations made in this Code. The process assists authorities to get started, identify Good Management Practice, identify current management practices, identify gaps, prioritise improvement and develop an implementation plan.

11.1 PURPOSE

- 11.1.1 The purpose of this section is to assist in the implementation of the Good Management Practice recommended in this Code. This is achieved by providing a process that can be used to identify the current management gaps (i.e. the difference between current practice and Good Management Practice), prioritise the needs, assess resource needs and costs, and plan implementation.



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- 11.1.2 The process, as presented, does not suggest timescales or advocate a specific order of implementation. It is the responsibility of the authority to identify an appropriate implementation timeframe and the specific order in which to implement Good Management Practice, while giving due consideration to any wider agenda they need to align with.

11.2 REQUIREMENTS

- 11.2.1 An implementation plan should be developed that clearly identifies how and when the authority seeks to achieve the Good Management Practice identified in this Code. The plan should be implemented.
- 11.2.2 Departures from the recommendations made in the Code should be fully recorded in the implementation plan and in appropriate policy or service standard documents.
- 11.2.3 The bridge manager, or the asset management representative for highway structures, should coordinate and manage the implementation of the Code as a formal project.

11.3 PRINCIPLES

- 11.3.1 Implementation of new practices, and/or the improvement of existing practices, should be addressed through a formal process that creates a systematic, logical and objective approach to identification, prioritisation and planning.
- 11.3.2 The formal process should be used to fully assess and challenge needs, evaluate costs and resources, set a realistic timeframe and develop an implementation plan. An implementation plan reduces the likelihood of practices being implemented in the wrong sequence, abortive work being carried out and inefficient use of resources.
- 11.3.3 Realising the implementation plan can be a difficult, time consuming and costly exercise and may easily lose focus and impetus if inadequately planned, managed and/or funded. In order to provide focus, the implementation plan should be treated as a formal project and should have a project manager and agreed milestones, resources and budgets.

11.4 GETTING STARTED

- 11.4.1 The Code contains a large body of information on highway structures management and it is recognised that a phased approach is necessary for full implementation. Authorities should adopt a formalised approach to examining, understanding, implementing and ongoing use of the Code. A suitable process for 'Getting Started' (i.e. initial review and developing understanding) is suggested in Figure 11.1.

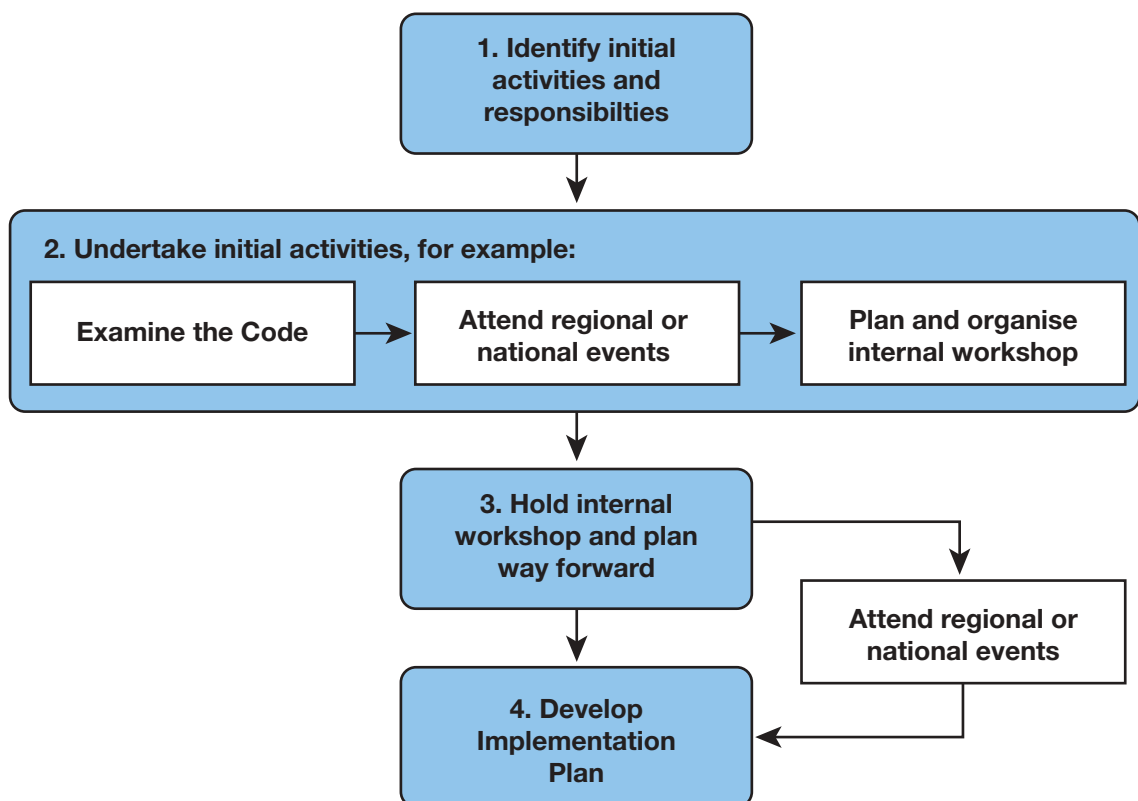


Figure 11.1: Getting started with the Code

11.4.2 The steps of the process shown in Figure 11.1 are:

1. **Identify initial activities and responsibilities** – should be undertaken by the bridge manager or the asset management representative for highway structures and should include identification of the initial activities to be undertaken, who is responsible for them, and the timeframe and what is deliverable from each.
2. Undertake initial activities – these may include:
 - a. **Examine the Code** – initially this should be a high level examination with the aim of gaining an early understanding of the Code and identifying requirements placed on the authority. Individual sections of the Code may be studied by different personnel as appropriate, but the bridge manager should maintain an overview of the whole Code.
 - b. **Attend regional or national events** – representatives from the authority should attend regional or local events that are designed to disseminate the guidance and key requirements given in the Code to all relevant personnel within the authority, including senior management. Authorities are recommended to work together and organise regional working groups to facilitate implementation of the Code.
 - c. **Plan and organise an internal workshop** – the bridge manager should organise an internal workshop involving all concerned, including contracted staff, to draw together the initial activities. It may be beneficial for senior personnel from the authority to attend all, or part, of the workshop in order to secure their commitment to the adoption of the Code.
3. **Hold internal workshop and plan the way forward** – the aim of the internal workshop should be to share knowledge from the initial activities (undertaken in Step 2) and to plan the way forward for the authority. This should include, but not be limited to:
 - a. Discussing the preparation of an implementation plan for the Code as described in Section 11.5 and setting out aspirations and broad timescales.
 - b. Identifying those responsible for the detailed review of the Code and the development of the implementation plan.
 - c. Identifying additional regional/national events to attend.
 - d. Agreeing on coordinated working with neighbouring authorities.
 - e. Aligning implementation of the Code with the authorities overall approach to highway asset management [1] and the implementation of the road and lighting Codes of Practice [2 & 3].
4. **Develop an implementation plan** – as described in Section 11.5 below.

11.4.3 The importance of the ‘Getting Started’ phase should not be overlooked as it provides the basis for the more involved task of developing the implementation plan. Authorities should **not** start to develop an implementation plan until the ‘Getting Started’ phase has been successfully completed.

11.5 DEVELOPING AN IMPLEMENTATION PLAN

11.5.1 The process for developing and reviewing the implementation plan is shown in Figure 11.2.

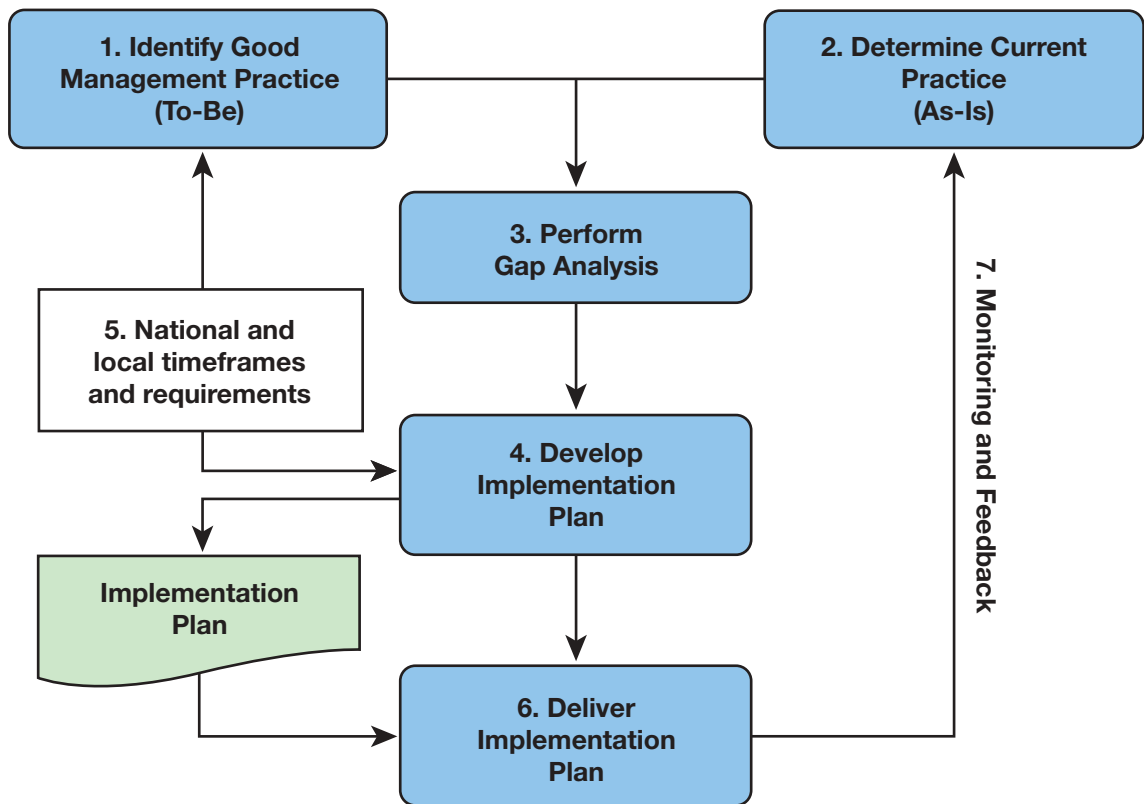


Figure 11.2: Process for developing an implementation plan

11.5.2 The components of the process shown in Figure 11.2 are:

1. **Identify Good Management Practice (To-Be)** – the desired practice should be taken as the Good Management Practice recommendations provided by the Code (see Section 11.6).
2. **Determine Current Practice (As-Is)** – a review of the current management practices to determine the starting position (see Section 11.7).
3. **Perform Gap Analysis** – a comparison of the As-Is and To-Be practices to identify the gaps. The gap analysis should include an assessment of costs and resources required to close the gaps, the benefits of closing the gap and the resources/training needed to sustain the To-Be position once in place. The identified gaps are prioritised using relevant criteria (see Section 11.8).
4. **Develop Implementation Plan** – convert the gap analysis into a formal implementation plan. The plan should identify the activities and timeframes together with the resources required to achieve it (see Section 11.9).
5. **National and local timeframes and requirements** – the implementation plan should be informed by these timeframes and requirements. In some cases this may necessitate a revision of the plan.

6. **Deliver Implementation Plan** – implementation and delivery of the plan as a formal project.
7. **Monitoring and Feedback** – practices should be periodically reviewed to assess the effectiveness of the implementation plan. If necessary the implementation plan should be revised.

11.6 IDENTIFY GOOD MANAGEMENT PRACTICE (TO-BE)

- 11.6.1 A staged review of the Code should be undertaken through a properly planned examination and dissemination, possibly through special team meetings, to assist full coverage and understanding and to deliver maximum benefit. The aim should be to ensure the Code is read and that what it contains and recommends is known and understood. The review should seek to establish local commitment to and development of the Good Management Practice identified by the Code.
- 11.6.2 The Good Management Practice described in the Code is embodied at the end of each section in recommendations and supporting actions, where the actions are grouped under three milestones. The recommendations, actions and milestones are described below.

Recommendations

- 11.6.3 The recommendations are normally in the form of high level goals that the authority should seek to achieve. The recommendations made by the Code are:
 1. Suitably qualified and experienced personnel, including contracted staff, should be used to implement the Good Management Practice embodied in this Code. There should be a programme of training and Continuing Professional Development (Section 2).
 2. Up-to-date background information should be maintained on the overall management context to provide an appropriate basis for meeting the requirements and regulations for the management of highway structures. This should include Government transport policy, the authority's transport policy, legal, Health and Safety, environmental, and sustainability requirements (Section 2).
 3. An Asset Management Regime should be developed for highway structures that is appropriate to the size and character of the stock. The regime should seek to be consistent with those for other transport assets (Section 3).
 4. A highway structures representative should be appointed to the authority's asset management team (Section 3).
 5. A robust long term asset management planning process should be developed and implemented for highway structures (Section 3).
 6. Performance measures and targets should be established for highway structures which align with and support the strategic goals and objectives and Levels of Service (Section 3).
 7. Financial plans should be prepared covering short, medium and longer term time horizons for the maintenance of highway structures. The plans

should provide the basis for targeting investment in achieving the authority's Strategic Transport Plan, e.g. LTP or LIP (Section 4).

8. Appropriate policies and procedures should be implemented for the accounting of expenditure on structures in accordance with financial reporting standards, established accounting practices and guidance (Section 4).
9. Appropriate policies and procedures should be implemented for the asset valuation of highway structures for inclusion in the authority's Balance Sheet. The valuation should follow financial reporting requirements and guidance provided in *CSS Guidance Document for Highway Infrastructure Asset Valuation* (Section 4).
10. A formalised maintenance planning and management process should be implemented that identifies needs, prioritises maintenance and produces cost effective and sustainable short to medium term work plans that are consistent with the long term Transport Asset Management Plan. The processes should cover the complete maintenance planning and management cycle (Section 5).
11. An inspection regime should be implemented for all highway structures, supplemented by testing and monitoring where appropriate. The inspection regime should include Acceptance, Routine Surveillance, General, Principal, Special and Safety Inspections as necessary (Section 6).
12. A regime of structural reviews should be implemented whereby the adequacy of structures to carry the specified loads is ascertained when there are significant changes to usage, loading, condition or the assessment standards. A structural review should identify structures which need a full assessment (Section 7).
13. A prioritised programme of structural review should be put in place to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards. Where a requirement for assessment is identified, such assessments should be carried out in accordance with national standards which are current at the time (Section 7).
14. All owners or managers of highway structures should establish and maintain a system to receive notifications from hauliers in respect of General Order abnormal load movements. The system should enable hauliers to be advised within the statutory time limits if there is any reason why the movement should not proceed. The system should also be able to manage the movement of Special Order vehicles in accordance with national standards and regulations (Section 8).
15. Information requirements for implementing Good Management Practice should be established and gaps in current information identified. A prioritised programme should be put in place to capture missing information (Section 9).
16. Data and information capture, verification, transfer and storage processes and practices should be established and continually reviewed (Section 9).

17. A Bridge Management System appropriate to the size and characteristics of the highway structures stock and needs of the authority should be implemented to support the Good Management Practice set out in this Code (Section 10).

Actions

- 11.6.4 In order to implement each recommendation, one or more supporting actions need to be undertaken. The actions are presented in a tabular format at the end of each section, after the recommendations. The actions are repeated below (after the description of the milestones) for ease of reference during the development of the implementation plan.

Milestones

- 11.6.5 The actions at the end of each section are divided into three milestones. The three milestones are defined as:
 1. **Milestone One** is intended broadly to include the adoption of processes necessary to provide highway structures that are *safe to use, inspect and maintain*.
 2. **Milestone Two** encompasses Milestone One and is also intended broadly to include the adoption of additional processes necessary to provide highway structures that are *fit for purpose* and meet Government requirements. Milestone Two represents an interim step on the progression towards Milestone Three.
 3. **Milestone Three** encompasses Milestones One and Two and additionally requires the adoption of processes necessary to deliver the agreed Levels of Service (and Performance Targets) at minimum whole life costs and to align with current and emerging Government policy objectives. This represents the full implementation of the Good Management Practice set out in this Code.
- 11.6.6 The milestones should be achieved in the order shown. However, this does not preclude progressing some actions in **Milestone Three** before **Milestone Two** is fully achieved. Progressing **Milestone Two** and **Three** actions should not delay achievement of **Milestone One**, which should be completed as a matter of urgency.
- 11.6.7 Many of the distinctions made between **Milestones Two** and **Three** are based on pre-requisite requirements, i.e. one process needs to be implemented in **Milestone Two** before an authority can successfully progress with a particular process in **Milestone Three**.
- 11.6.8 The Code does not give timescales for achieving the milestones. It is for the authority to decide on timescales bearing in mind national requirements, local needs and priorities, and constraints on resources and funding.
- 11.6.9 The actions in each milestone are summarised in the following tables.

Milestone One Actions
<p>Section 2: Structure Management Context</p> <ul style="list-style-type: none"> • Employ suitably qualified, experienced and trained personnel (Section 2.2). • Provide a programme of CPD and training for bridge managers, engineers and other staff to enable them to understand and implement the processes necessary to provide highway structures that are safe to use, inspect and maintain (Section 2.2). • Require agents and contractors to demonstrate their personnel are adequately qualified and experienced and are provided with appropriate CPD and training (Section 2.2). • Maintain up-to-date documents on Government transport policy and plans (Section 2.3) and Best Value, or equivalent, legislation (Section 2.4). • Maintain information on legal and procedural requirements (Section 2.6). • Maintain a Health & Safety policy and associated guidance notes tailored for the specific operations involved in the management of highway structures (Section 2.7). • Maintain appropriate standards for maintenance (Section 2.8). • Maintain a Technical Approval Procedure with an organisation or individual formally appointed as TAA (Section 2.8).
<p>Section 3: Structures Asset Management Framework</p> <ul style="list-style-type: none"> • Nominate a highway structures representative to the asset management team (Section 3.3).
<p>Section 4: Financial Planning and Resource Accounting</p> <ul style="list-style-type: none"> • Establish proper policies and procedures for the capitalisation of expenditure on structures maintenance, renewal and enhancement (Section 4.6).
<p>Section 5: Maintenance Planning and Management</p> <ul style="list-style-type: none"> • Check that the inputs to the maintenance planning and management process are in place (Section 5.6). • Implement a formal emergency response process (Section 5.7). • Implement a formal process for identification of needs (Section 5.10). • Develop and implement an annual work plan that covers reactive maintenance (Section 5.14). • Identify how maintenance work should be classified (Section 5.5).
<p>Section 6: Inspection, Testing and Monitoring</p> <ul style="list-style-type: none"> • Implement a regime of Routine, Safety, Special and Acceptance Inspections covering all highway structures and any necessary testing and monitoring (Section 6.4). • Implement a regime of General Inspections at an interval of not more than two years, covering all highway structures (Section 6.4). • Implement a process whereby the inspector has a clearly defined duty to inform the bridge manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety (Section 6.5). • Implement a monitoring regime for all sub-standard structures (Section 6.7).
<p>Section 7: Assessment of Structures</p> <ul style="list-style-type: none"> • Complete the already defined national programme for 40 tonne assessment loading and take appropriate actions arising from the assessments, including any interim measures. • Check that assessments results are properly recorded and kept up-to-date (Section 7.6).

Milestone One Actions (continued)
<p>Section 8: Management of Abnormal Loads</p> <ul style="list-style-type: none"> • Establish the roles of Abnormal Loads Officer, Structures Adviser, and Road Space Coordinator as specified in the Code (Section 8.2). • Establish procedures to check the suitability of a specific abnormal load to cross a particular structure, broadly in accordance with the procedures given in Annex D of BD86 (Sections 8.5 and 8.6). • Establish an Elementary System for the management of abnormal loads (Section 8.6).
<p>Section 9: Asset Information Management</p> <ul style="list-style-type: none"> • Identify data and information needs (Sections 9.5 and 9.6). • Review current data and information (Section 9.5). • Undertake a gap analysis and schedule data capture (Section 9.5). • Establish data capture, verification, transfer and storage processes and practices (Section 9.5). • Capture essential data (Section 9.6). • Establish Structure Files (Section 9.7).
<p>Section 10: Framework for a Bridge Management System</p> <ul style="list-style-type: none"> • The BMS should have a database with a listing of all highway structures with basic inventory details recorded for each asset. It would be preferable to store inspection results on the BMS (Section 10.8).

Milestone Two Actions
<p>Section 2: Structure Management Context</p> <ul style="list-style-type: none"> • Establish a process for compiling, storing and maintaining information on the management context of highway structures. Ensure the information is readily accessible and the process has a mechanism for keeping relevant staff informed of changes, amendments, updates, etc. (Section 2.1). • Provide a programme of CPD and training for bridge managers, engineers and other staff to enable them to understand and implement the processes of Good Management Practice described in this Code (Section 2.2). • Maintain up-to-date documents on Resource Accounting and Budgeting requirements (Section 2.5). • Maintain guidance notes on the environmental (Section 2.9) and conservation (Section 2.11) requirements for management of highway structures. • Maintain procedures for stakeholder consultation and involvement (Section 2.12). • Produce and maintain guidance notes, as appropriate, for dealing with other owners and third parties, e.g. developer promoted structures and structures over/adjacent to railways or canals (Section 2.13).

Milestone Two Actions (continued)
<p>Section 3: Structures Asset Management Framework</p> <ul style="list-style-type: none"> • Determine the content and scope of the Asset Management Regime that is appropriate for the authority's highway structures stock and align the Regime with the regimes for other transport assets (Section 3.5). • Translate strategic goals and objectives and Levels of Service into performance targets for highway structures (Section 3.7). • Identify the components of the Asset Management Regime that need to be developed for Basic and Advanced AM Planning (Section 3.7). • Develop and implement components of the AM Regime needed to deliver the Basic AM Planning process for highway structures (Section 3.7).
<p>Section 4: Financial Planning and Resource Accounting</p> <ul style="list-style-type: none"> • Prepare a Medium Term Financial Plan to support funding processes such as LTP, Spending Reviews, etc (Section 4.5). • Prepare Annual Financial Plan to provide a basis for setting the Annual Budget (Section 4.5). • Adopt the recommended procedures for determining commuted sums (Section 4.8).
<p>Section 5: Maintenance Planning and Management</p> <ul style="list-style-type: none"> • Store the data required for maintenance planning and management in a suitable format (Section 5.8) and determine current performance (Section 5.9). • Develop and implement a regular maintenance regime (Section 5.10). • Develop and implement lifecycle plans for common forms of bridge construction (Section 5.10). • Develop and implement Value Management (Section 5.11). • Develop and implement an Annual Work Plan that covers regular, programmed and reactive maintenance (Section 5.14). • Implement a feedback loop to monitor and review delivery of the Annual Work Plan (Section 5.16). • Identify and implement improvements to the maintenance planning and management process (Section 5.17).
<p>Section 6: Inspection, Testing and Monitoring</p> <ul style="list-style-type: none"> • Implement a regime of Principal Inspections at an interval of not more than six years, covering all highway structures except those where a Principal Inspection would not add significantly to the defects picked up by a General Inspection (Section 6.4). • Record the severity and extent of defects during General and Principal Inspections. It is recommended that the CSS Inspection Guidance, or a similar approach, is used (Section 6.5). • Produce a full report for each Principal Inspection (Section 6.5). • Carry out regular in-house inspection meetings to assess the consistency and competence of inspectors OR check that external contractors have suitably qualified/experienced inspectors who are also reviewed on a regular basis (Section 6.5).
<p>Section 7: Assessment of Structures</p> <ul style="list-style-type: none"> • Implement a regime of structural reviews and reassessments as defined in the Code (Section 7.4). • Put in place a prioritised programme of structural reviews to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards (Section 7.4). • Store the assessment results in a Bridge Management System (Section 7.6).

Milestone Two Actions (continued)
<p>Section 8: Management of Abnormal Loads</p> <ul style="list-style-type: none"> • Establish how and to what extent the Authority will use the ESDAL system, when available, in particular the facility for Indicative Capacity Appraisals. Accordingly make the necessary data available to the ESDAL System (Section 8.6). • Establish an Advanced System for the management of abnormal loads as appropriate to work alongside the ESDAL System (Section 8.6).
<p>Section 9: Asset Information Management</p> <ul style="list-style-type: none"> • Capture remaining data and information (Sections 9.5 and 9.6). • Programme cyclic data and information needs (Section 9.5).
<p>Section 10: Framework for a Bridge Management System</p> <ul style="list-style-type: none"> • The BMS should incorporate the following functional modules: • User Interface (Section 10.5). • Report Generator (Section 10.7). • Asset Database (Section 10.8). • Works Management (Section 10.9). • Abnormal Load Management (Section 10.10). • Performance Measures (Section 10.13). • Decision Support for short term planning and Basic AM planning (Section 10.6).

Milestone Three Actions
<p>Section 2: Structure Management Context</p> <ul style="list-style-type: none"> • Continue to provide an on-going programme of CPD (Section 2.2). • Produce and maintain a guidance note on the ownership and maintenance of retaining walls and, as appropriate, a protocol for dealing with cellars and vaults and flooding at culverts (Section 2.6). • Produce and maintain a guidance note on the sustainability requirements for the management of highway structures (Section 2.10).
<p>Section 3: Structures Asset Management Framework</p> <ul style="list-style-type: none"> • Develop and implement components of the AM Regime needed to deliver the Advanced AM Planning process for highway structures (Section 3.7).
<p>Section 4: Financial Planning and Resource Accounting</p> <ul style="list-style-type: none"> • Prepare an integrated long term Transport Asset Management Plan, Medium Term Financial Plan and Annual Financial Plan as recommended. The plans should represent consequences of under-funding, by say 10%, 20% and 30% (Section 4.5). • Establish a regime for the asset valuation of highway structures in accordance with the CSS Guidance Document (Section 4.7).

Milestone Three Actions
<p>Section 5: Maintenance Planning and Management</p> <ul style="list-style-type: none"> • Develop and implement lifecycle plans for all groups and sub-groups of highway structures (Section 5.10). • Develop and implement Value Engineering (Section 5.12). • Develop and implement a Forward Work Plan for the next 1 to 3 years (Section 5.13) and monitor delivery (Section 5.16). • Organise the different components of the maintenance planning and management process into a complete and integrated process (Section 5.4) and align with the long term asset management planning process (Section 3.7).
<p>Section 6: Inspection, Testing and Monitoring</p> <ul style="list-style-type: none"> • Implement a regime of Principal Inspections covering all highway structures. Where appropriate, use risk assessment to determine the inspection interval (Section 6.4). • Produce an inspection, testing and monitoring manual that clearly defines the inspection requirements for the authority with H&S, Environmental and Conservation information recorded for each structure (Sections 2 and 6).
<p>Section 7: Assessment of Structures</p> <ul style="list-style-type: none"> • Utilise assessment results in the planning and management of future maintenance programmes.
<p>Section 8: Management of Abnormal Loads</p> <ul style="list-style-type: none"> • Ensure that the necessary data, including assessment results, are implemented and kept up-to-date within a Bridge Management System and used in the management of abnormal load movements (Section 8.5). • Establish and monitor communication links between the Bridge Management System and the ESDAL System as necessary (Section 8.6).
<p>Section 9: Asset Information Management</p> <ul style="list-style-type: none"> • Implement an on-going data and information review process (Section 9.5).
<p>Section 10: Framework for a Bridge Management System</p> <ul style="list-style-type: none"> • In addition to the above, the BMS should incorporate the following functional modules: • Prediction Models (Section 10.11). • Whole Life Costing (Section 10.12). • Asset Valuation (Section 10.14). • Decision Support for Advanced AM planning (Section 10.6).

11.7 DETERMINE CURRENT PRACTICE (AS-IS)

11.7.1 The current practice should be identified in a manner that aligns with the recommendations/actions (Section 11.6) and that enables the subsequent gap analysis to be readily performed. Two means of achieving this are:

1. **Basic Approach** - assess the actions given in Sections 2 to 10 and assign a *Fully, Partially* or *None* against each with respect to the authority's current practice.
2. **Refined Approach** - assess the actions given in Sections 2 to 10 and assign a rating to each with respect to the authority's current practice, where ratings are typically on a scale of 1 to 5 as described in the following.

11.7.2 Under a refined approach each action should be assigned to one of the following categories and assessed against the ratings given in Table 11.1.

1. **Processes and Systems** – the processes, procedures, tools and systems required for highway structures management.
2. **Data** – the data/information required to support highway structures management.
3. **People** – the number and competence of staff responsible for highway structures management.

Table 11.1 - Category ratings			
Rating	Processes and Systems	Data	People
1	Not in place – the need has not been recognised or the need has been recognised but no action has been taken.	Poor – data quality and quantity are below the level required to undertake basic management activities.	Unsatisfactory – competence below minimum requirements in many areas and/or severe staff shortages.
2	Implementation – the need has been recognised and a plan for implementation is currently being developed or is already being implemented.	Basic – inventory is adequate but condition and performance data is poor and incomplete.	Needs Improvement – staff competence below minimum requirements in some areas and/or some staff shortages.
3	Recently implemented – has been recently implemented and the authority is in the early stages of training and usage.	Fair – inventory is complete and there is sufficient condition and performance data to support basic asset management.	Satisfactory – meet minimum competence and resources requirements, but skills and capacity for innovation may be insufficient.
4	Established – has been in place for a number of years and as such is documented and associated training is in place, but it may not be fully integrated with other processes.	Good – inventory is complete and quantity and quality of condition and performance data is improving	Competent – competence and/or resource above minimum requirements, and skills and capacity available to promote innovation and improve efficiency.
5	Fully embedded – mature and fully documented, associated training is in place and it is integrated with other processes.	Comprehensive – all data is accurate, up-to-date and complete and sufficient to support advanced asset management.	Excellent – competence and resources above minimum requirements with suitable skills and capacity to actively innovate and improve efficiency.

11.8 GAP ANALYSIS

- 11.8.1 A gap analysis compares the As-Is position with the To-Be position. The objective of the comparison is to identify and assess where there are gaps in practice and prioritise actions needed to close the gaps. Gaps can be readily identified by using the basic or refined approach described in Section 11.7.
- 11.8.2 There are clear resource implications arising from any identified gap. Whilst there may be an economy of scale in doing everything at once, it is important to check this does not delay the meeting of prescribed statutory requirements and safeguarding the public. The following simple approach to the gap analysis is suggested:
1. Identify any gaps in relation to Milestone One actions and progress the actions needed to close these gaps as a matter of urgency.
 2. Identify any gaps in relation to Milestones Two and Three and evaluate the resources and budget required to close the gaps, and the associated benefits. Also identify actions that are, or have, pre-requisites.
 3. Prioritise closure of the Milestone Two and Three gaps.
- 11.8.3 Determining the resources required to support the Good Management Practice is a complex task. Authorities may find it beneficial to liaise with similar authorities to assess resource needs, e.g. some authorities may already have a number of practices in place and can use their experience to inform others of the resource needs.

Milestone One Gaps

- 11.8.4 Milestone One relates to providing highway structures that are safe to use, inspect and maintain. As such, if there are any gaps between current practice and Milestone One they should be closed as a matter of urgency in order to safeguard the travelling public, and protect the authority against legal action relating to sub-standard management.

Milestone Two and Three Gaps

- 11.8.5 Each gap should be assessed in relation to the resources and costs required to close the gap and sustain the subsequent Good Management Practice. The perceived benefits from closing the gap should also be assessed along with an estimate of the implementation period.
- 11.8.6 The exercise should identify any actions that can be progressed in parallel, in particular where this can result in cost efficiencies. It is also important to identify any actions that are pre-requisites of other actions.

Prioritise

- 11.8.7 The information gathered from the assessment of the Milestone Two and Three gaps should be used to prioritise actions needed to close the gaps. The prioritisation should be carried out by the bridge manager, or asset management representative for highway structures, based on the information at hand and through consultation and agreement with colleagues.

- 11.8.8 Guidance on performing a gap analysis is also provided in the *Framework for Highway Asset Management* [1].

11.9 IMPLEMENTATION PLAN

- 11.9.1 The information from the gap analysis should be combined with the realities of budget, resource and time constraints and developed into a practical and achievable implementation plan. This task should take into account any national or local requirements and timeframes that are likely to influence the implementation plan, e.g. the gaps that need to be closed to support the Strategic Transport Plan, e.g. LTP and LIP.
- 11.9.2 The implementation plan should contain the programme, document the gap analysis and identify the resources and budget required to support the plan and the subsequent Good Management Practice. The implementation programme should ideally cover the full period to reach Milestone Three.
- 11.9.3 The implementation plan should fully document any departures from the recommendations made in the Code, and provide supporting rationale for the departure. Departures should also be recorded in appropriate policy or service standard documents.
- 11.9.4 The implementation plan should be managed as a formal project and have a project manager (preferably the bridge manager or the asset management representative for highway structures), budget and resources allocated. The implementation plan should be reviewed annually and revised when appropriate.
- 11.9.5 Guidance on developing an implementation plan is also provided in the *Framework for Highway Asset Management* [1].

11.10 REFERENCES FOR SECTION 11

1. *Framework for Highway Asset Management*, County Surveyors Society, April 2004.
2. *Well-Maintained Highways: Code of Practice for Highway Management*, The Stationery Office, July 2005.
3. *Well-Lit Highways: Code of Practice for Highway Lighting Management*, ISBN 0 11552 632 3, The Stationery Office, November 2004.

Appendices

- A Sources of Information on Relevant Environmental Legislation
- B Standards for Maintenance
- C Guidance on Retaining Wall Responsibilities
- D Guidance on Culvert Waterway Capacity
- E Relevant Health and Safety legislation in England
- F Guide List of Consultees in England
- G Process Flowchart for Liaison with Network Rail
- H Process for Dealing with Developer Promoted Structures
- I Summary of Maintenance Techniques
- J Whole Life Costing
- K Prioritisation Systems
- L Undertaking Inspections
- M Selection of Test Houses and Specification and Procurement of Testing
- N Abnormal Load Categories

Appendix A

Sources of Information on Relevant Environmental Legislation

A.1.1 The following environmental legislation contacts were relevant at the time of publication of this Code (September 2005).

<p>Department for Environment, Food and Rural Affairs Tel: 08459 33 55 77 www.defra.gov.uk/environment/index.htm</p>	 <p>defra Department for Environment Food and Rural Affairs</p>
<p>Environment Agency (England and Wales) Tel: 0845 9333111 www.environment-agency.gov.uk</p>	 <p>ENVIRONMENT AGENCY</p>
<p>Environment and Heritage Service, Northern Ireland Tel: (028) 9025 1477 www.ehsni.gov.uk</p>	 <p>ENVIRONMENT AND HERITAGE SERVICE</p>
<p>Scottish Environment Protection Agency Tel: 01786 457700 www.sepa.org.uk</p>	 <p>SEPA</p>

Appendix B

Standards for Maintenance

Highways Agency

- B.1.1 The Highways Agency *Design Manual for Roads and Bridges (DMRB)* [1] and the *Manual of Contract Documents for Highway Works (MCDHW)* [2] are published by The Stationery Office (TSO) and are available from:

The Stationery Office

PO Box 29

Norwich NR3 1GN

Tel: 0870 600 5522

Email: book.orders@tso.co.uk or on-line via the TSO website www.tso.co.uk

- B.1.2 They can also be viewed on the Highways Agency website:

www.highways.gov.uk/business/tech_info.htm

- B.1.3 The DMRB provides detailed guidance in the form of standards (BDs) and advice notes (BAs) for most aspects of highway structure design and assessment. The guidance includes criteria for structural loading, analysis, material properties, element design or assessment, in addition to geometrical requirements and best practice for design for durability. The MCDHW provides model contract documents, specifications, notes for guidance and standard details.

- B.1.4 Care is required to remain fully aware of changes and additions to the DMRB and the MCDHW. This can be achieved by registering with The Stationery Office website (www.tso.co.uk) or by visiting the Highways Agency website (www.highways.gov.uk/business/tech_info.htm).

- B.1.5 The Highways Agency also issues Interim Advice Notes (IAN), as interim guidance until full standards are available, and a *Trunk Road Maintenance Manual (TRMM)* [3]. The former are on the Highways Agency website and both may be obtained from The Stationery Office. TRMM comprises three volumes:

1. Volume 1: Highway Maintenance Code
2. Volume 2: Routine and Winter Maintenance Code
3. Volume 3: Management of Health and Safety

Network Rail

- B.1.6 Network Rail has a range of company standards, which include specifications, codes of practice, procedures and technical instructions. These are available from:

HIS Technical Indexes
Willoughby Road
Bracknell
Berkshire RG12 8DW
Tel: 01344 404434
Email: marketing@ihsti.com
Website: www.ihsti.com

British Standards

- B.1.7 British Standards are available from:

BSI Customer Services
British Standards Institution
389 Chiswick High Road
London W4 4AL
Tel: 020 8996 9001
Email: cservices@bsi-global.com
Website: www.bsi-global.com

Appendix C

Guidance on Retaining Wall Responsibilities

- C.1.1 The legal and procedural requirements for retaining walls can be complex. It is suggested that an authority should produce and maintain a guidance note on the requirements for retaining walls.
- C.1.2 The following guidance was produced by and is used by Lancashire County Council (LCC). During development of the guidance, LCC sought the opinion of five other authorities in the north/north west region of England and Wales regarding maintenance responsibilities. The opinions of these authorities were found to be substantially in line with the following.
- C.1.3 The following guidance may not be suitable for all authorities. However, it is an example of good practice and may be used as a template for developing an authority specific note. In all cases authorities should seek legal advice on the suitability of the proposed policy for detailing with their retaining walls.

LCC guidance on retaining wall responsibilities

Definition

- C.1.4 Retaining walls within the highway boundaries may be classified as follows:
1. Those which directly support the highway or support an embankment carrying the highway are referred to as 'highway retaining walls'.
 2. Those which support land and/or property which is alongside and above the level of the highway are referred to as 'property retaining walls'.

Determining the Responsibility for Maintenance

- C.1.5 For most modern highways, the responsibility for the maintenance of the retaining walls will be recorded on LCC bridge files or information sheets, etc. Where there are no such records, the responsibility for the maintenance, on modern roads and on some older roads, may be recorded on the Deeds of Conveyance for the adjoining land (usually in the possession of the landowner). This responsibility may be recorded in the form of an easement granted to the highway authority for access for maintenance, or in some other form.
- C.1.6 In many cases the construction and maintenance of retaining walls, particularly of property retaining walls, was dealt with as 'accommodation works' and responsibilities agreed in an exchange of letters between the highway authority and the landowner, without any reference being incorporated in the Deeds of Conveyance. Such letters may now be missing or destroyed. Nevertheless the identification of the maintenance responsibilities where there is doubt, should generally be attempted by thoroughly searching the bridge files and the legal documents library in Legal Services, requesting information from the Lands Registry and examining the Deeds of Conveyance provided by the landowner. No responsibility for the maintenance of a property retaining wall and, in some

cases highway retaining walls (e.g. retaining walls which may have been outer walls of mills), shall be accepted without an examination of the Deeds.

- C.1.7 However, in the absence of any unusual circumstances, highway retaining walls which are within the highway boundaries can generally be assumed to be a County Council responsibility without resort to the more detailed searches, external to the Environment Directorate, which are referred to in the paragraph above. For all other walls, if the searches do not reveal any relevant evidence, then the responsibility for maintenance shall be determined on the likely purposes for which the wall was built.
- C.1.8 The purpose for which a wall was built can often be determined by the digging of a trial hole, or by taking a borehole (possibly by hand auger), a short distance behind the wall. If the retaining wall is found to be supporting the original ground then, if it is a property retaining wall, it can be assumed to have been constructed for highway purposes. If it is a highway retaining wall it can be assumed to have been constructed for the benefit of the property owner. If the retaining wall is found to be supporting filled ground then the converse should be assumed to apply.
- C.1.9 Where a property retaining wall is of similar construction and vintage as the property it supports, boreholes or trial holes will often not be necessary since it can be assumed that the wall was constructed to support the property, and hence is the property owner's responsibility.

Fence Walls

- C.1.10 Retaining walls are often surmounted by integral or free standing fence walls (or boundary walls). It should be noted that a highway authority does not have any legal obligation to fence off a highway. Hence most of the fence walls alongside the highway are not maintained by the highway authority. The highway authority does however have a general duty of care to ensure the safety of the public, including highway users. Hence, where the responsibility for the maintenance of a retaining wall rests (or is assumed to rest) with the County Council a parapet shall be provided on the top of the retaining walls in appropriate situations.
- C.1.11 In the case of highway retaining walls a judgment will need to be made in deciding whether a parapet is appropriate and the type of parapet which should be provided. Reference should be made to appropriate Highway Agency Standards and Advice Notes when making this judgment. In the case of property retaining walls a timber fence parapet will usually be adequate, but consideration should be given to likely planning requirements if subject to a planning application, e.g. the need to provide a masonry wall to match adjoining boundary walls.

Contributions to the Cost of Maintenance

- C.1.12 Contributions should be sought:
1. Where a boundary wall is provided at the request of a property owner in lieu of a timber fence or other less costly parapet which would be adequate for highway and planning approval purposes.
 2. For betterment or deferment of renewal where a boundary wall needs to be rebuilt even where the rebuilding is as a result of the collapse of the retaining wall beneath, and a less costly parapet would suffice for highway purposes.

3. Where a property owner derives a substantial benefit from the presence of a property retaining wall, for the support of development that has taken place after the wall was constructed.

Summary		
Type of Wall	Responsibility	Other Comments
A. Walls Supporting the Highway		
1. Provided when the highway was constructed.	Highway Authority (HA) unless other agreement.	
2. Provided when the road was altered in line or level for private needs – canal, railway, etc.	Private.	HA may have to take action if responsibility not accepted by others.
3. Originally not retaining but now retaining due to increase in height of highway through resurfacing, etc.	HA (for maintenance only) if repair is necessary for the support of the highway or attributable to the effect of the highway.	Avoid this possibility by making highway self supporting.
4. Originally not retaining but now retaining due to decrease in level of land through farming, etc.	Private.	HA may have to take action to support the highway. It may be difficult to prove an obligation on the landowner to provide support.
5. Walls formerly incorporated in a building and remaining after demolition or walls provided for private benefit, e.g. to provide level area on sloping ground.	Private.	Any wall adjoining land owned by LCC should be incorporated in the sale of any plot.
B. Walls Supporting Adjacent Land		
1. Provided when the highway was constructed.	HA unless other agreement.	HA to accept responsibility if the landowner does not.
2. Provided when the road or land was altered in line or level for private needs.	Private.	HA may need to remove debris or otherwise take action and recharge the owner.
3. The factors surrounding the construction of the wall not determined.	Depending on results of site investigation (see paragraph C.1.8 above).	Each case to be determined on questions of fact. HA initially need to remove debris or otherwise take action.
C. Fence Walls		
1. Fence wall integral with and of monolithic construction with a retaining wall.	Same as for retaining portion – but only over the length of retaining wall.	In event of repair being necessary HA to determine if there is an obligation or a highway need for the wall.
2. Fence wall not connected with a retaining wall.	Private unless other agreement .	Problems may arise if it now retains fill (see A4 above).

Appendix D

Guidance on Culvert Waterway Capacity

D.1.1 Deciding on the waterway capacity that should be provided for new or replacement culverts or on whether to intervene following flooding is a complex matter. It is suggested that a highway authority should produce and maintain a guidance note on this topic.

D.1.2 The following guidance is used by Kent County Council and may not be suitable for all highway authorities. However, it is an example of good practice and may be used as a template for developing an authority specific note.

Kent CC guidance on culvert waterway capacity: strategy on standards of design for new works and intervention after flood events

D.1.3 Following the judgement in the Bybrook [4] case that a highway authority can eventually be liable for the consequences of a loss in capacity of a culvert in its ownership arising from changes brought about by others, it was considered that some guidance was needed on how to react to other scenarios brought to attention as a result. Even without the Bybrook case it is clear that some action in mitigation of the effects of flooding would have been necessary as a result of the MAFF High Level Targets Initiative [5].

D.1.4 It is important to note four things arising from the judgement:

1. That the strong view of all those involved with the litigation is that the judgement is case specific and depends on its own facts.
2. That prior knowledge of a flooding problem would appear to be a prerequisite to a charge of nuisance being successful.
3. That it is not necessary for the authority to shoulder the burden of resolving the problem alone, but a test of “reasonableness” will be made against their response to any complaint received.
4. Interference will be judged on its effect on the natural flow and its ability to cope with an extraordinary event. In this latter regard it will be reasonable to assume the Environment Agency’s design return period standard for the site as being adequate.

D.1.5 For the purposes of this statement the following definitions will apply until such time as clearer guidance is received:

1. Natural Flow - flow to the top level of the lowest of the two banks in the area upstream of the culvert.
2. Extraordinary Event - the frequency of return event required to be accommodated by the Environment Agency at the site in question.

- D.1.6 There are four potential levels of investigation necessary to determine the natural and extraordinary flow capacity required of culverts in new works or brought to light as a flood risk, namely:
1. Full hydrological survey identifying catchment area and volume/rate of run off.
 2. Utilisation of existing comparable data/statistics.
 3. Pragmatic assessment of existing stream and/or culvert capabilities upstream and downstream of the culvert site.
 4. Matching or exceeding present culvert capacity where one exists and there is no known adverse consequences of flood events.
- D.1.7 In considering all of these, due account must be taken of any known impending changes or future plans which might affect the situation.
- D.1.8 It seems reasonable to suppose that a culvert which matches or exceeds the capacity of the upstream ditch cannot be deemed to be interfering with the natural flow. In such situations the difficulty then is in determining the needs to accommodate the 'extraordinary' design return event. It is entirely possible that both could be contained within the natural ditch.
- D.1.9 The experience and knowledge of Environment Agency (EA) officers in this regard will be invaluable in limiting the extent to which limited funds have to be used on full-scale hydrological surveys. Their advice in assisting highway authorities to prepare their schemes for submission for approval will be crucial to dealing with the potential fall out from this judgement. Where there is clear evidence that a problem has arisen as a result of some action by others then it is entirely reasonable for the highway authority to seek recompense from the offending party where this can be adequately quantified.
- D.1.10 As intimated in paragraph D.1.7 above there can be no greater capacity than to remove a culvert altogether and return to the open ditch. To provide a culvert of greater than the open ditch capacity cannot therefore be deemed as interference with the flow in respect of properties downstream. In the event that the EA identify a problem arising from the removal of the interference then they will have to specify what might need to be done in mitigation. Although there can be no legal requirement for the highway authority to carry out such work, or at least to do so at their own expense, co-operation has to be the way forward.
- D.1.11 Table D.1 suggests a level of reaction for different circumstances and operates within the process shown in Figure D.1.

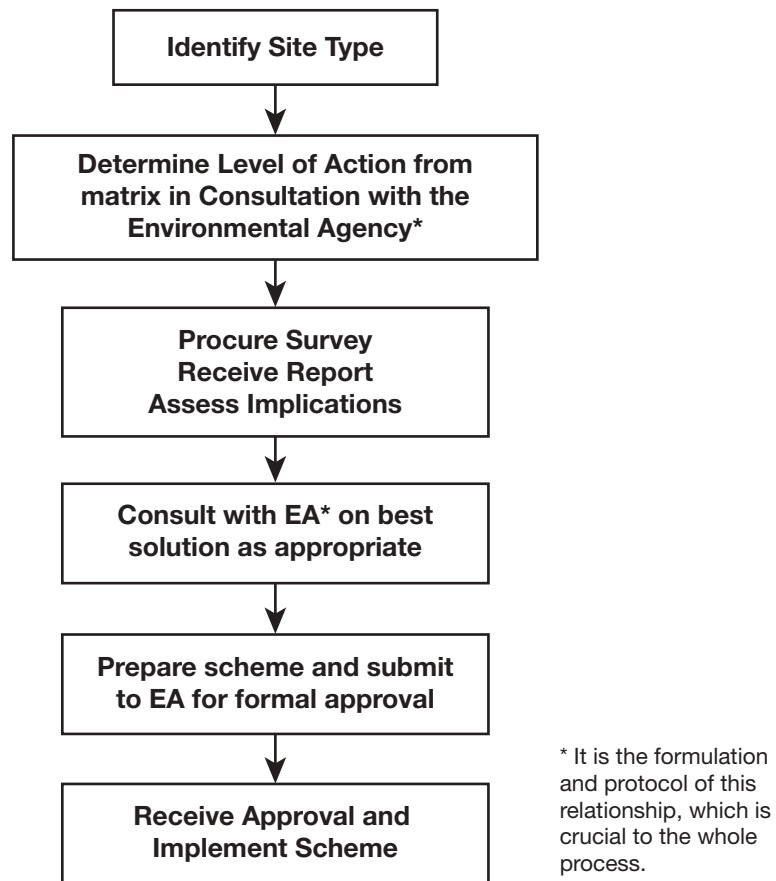


Figure D.1: Process for schemes that influence culvert waterway capacity

- D.1.12 In the event that an existing culvert is found to be adequate and the reported event causing flooding is in excess of the design standard for the site then no action is necessary. This does not preclude a decision to cater for a longer return period event being taken.
- D.1.13 In the event that a shortfall in capacity is identified then it is reasonable to seek financial and practical support as appropriate from both those affected by the flooding and those causing increased run off by their upstream activities in resolving the problem.
- D.1.14 It is important to ensure that **all** developments deal fully with the consequences of their work both in local attenuation facilities and knock-on mitigation works. They should routinely be required to produce a hydrological statement as part of their environmental assessment. County and District planners must be made aware of this fact.

Table D.1 - Levels of reaction based on scheme characteristics				
	Full hydrological survey	Utilisation of comparable data/statistics capabilities (EA to assist)	Assessment of existing stream (EA to assist)	Comparisons with existing facility(ies) (EA to assist)
New Highway Improvement Scheme	✓*	✓*		
New development schemes	✓*	✓*		
Reconstruction of Culverts				
• Urban Area - sensitive to flooding	✓			
• Urban Area - little flood history		✓	✓	
• Rural Area - sensitive to flooding		✓	✓	
• Rural Areas - not sensitive to flooding			✓	✓
Consideration of Advised Flood Spots				
• Non Main River/Critical Water Course	✓			
• Non Critical Water Course				
• Properties Flood		✓	✓	
• No properties flood			✓	✓
• Main River	EA to determine			

* Depends upon scale of scheme

Summary of main pro-active actions

1. Identify, through District Councils, flood spots, especially on critical ordinary watercourses, as part of MAFF High Level Target Initiatives and review capacities as suggested in Table D.1.
2. Ensure that all Development Schemes produce a Hydrological Statement identifying their effect on the existing drainage infrastructure. This must be carried out by a competent person or organisation. Emphasise the need for this to all Planning Authorities.
3. Agree a protocol of consultation/liaison with EA Regional Office. Identify their return event design standards.
4. Determine and implement programme of inspection/cleansing of flood sensitive sites and those protected by upstream grilles. Review regularly in light of storm/flooding events.
5. Ensure improved records in future and greater clarity and accuracy of fact in future statements.
6. Avoid negative unhelpful replies to complainants. It is important to stress adequacy of culvert and extremeness of event where appropriate and perhaps suggest things they may do in mitigation, including perhaps enlarging the culvert where the highway authority perceives it to be adequate for its obligations.

Appendix E

Relevant Health and Safety Legislation in England

E.1.1 The following Health and Safety legislation was relevant in England at the time of publication of this Code (September 2005). The list may not be comprehensive and should therefore be reviewed to identify other Health and Safety legislation relevant to the management of highway structures.

E.1.2 The current status of the following legislation should be checked before use. The list should be updated as legislation is amended, added and removed

Principal Act

- Health & Safety at Work Act etc 1974 (HSWA)

Regulations

- Management of Health and Safety at Work Regulations 1999 (MHSW)
- Workplace (Health, Safety and Welfare) Regulations 1992
- Provision and Use of Work Equipment Regulations 1998 (PUWER)
- Manual Handling Operations Regulations 1992
- Health and Safety (Display Screen Equipment) Regulations 1992
- Personal Protective Equipment at Work Regulations 1992 (PPE)

Construction & Site Legislation

- Construction (Health, Safety and Welfare) Regulations 1996
- Construction (Design and Management) Regulations 1994 (CDM) (Amended in 2002 to provide clear guidance on the responsibilities of Designers)
- Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)
- Control of Asbestos at Work Regulations 2002
- Control of Lead at Work Regulations 2002 (CLAW)
- Confined Spaces Regulations 1997
- Construction (Head Protection) Regulations 1989
- Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972

- Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)
- Control of Substances Hazardous to Health Regulations 2002 (COSHH)
- Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP)
- Electricity at Work Regulations 1989
- Health and Safety (Safety Signs and Signals) Regulations 1996
- Safety Representatives and Safety Committees Regulations 1997
- Employer's Liability (Compulsory Insurance) Regulations 1998

Fire Safety Legislation

- Fire Precautions Act 1971 (FPA)
- Fire Precautions (Workplace) Regulations 1977 (as amended)
- Fire Precautions (Sub-surface Railway Stations) Regulations 1998

Laboratory Specific Legislation

- Ionising Radiation Regulations 1999

Railway Specific Legislation

- Railway (Safety Case) Regulations 2002
- Railway (Safety Critical Work) Regulations 1994
- Railways Act 1993
- Railways and Other Transport Systems (Approval of Works, Plant and Equipment) Regulations 1994
- Transport and Works Act 1992
- Working Time Regulations 1998 (amended 1999, 2001)
- Diving at Work Regulations 1997

Highways Specific Legislation

- New Roads and Street Works Act 1991
- Traffic Management Act 2004
- Highways Act 1980

Miscellaneous Legislation

- Asbestos (Licensing) Regulations 1983 (amended 1989)
- Supply of Machinery (Safety) Regulations 1992
- Electrical Equipment for Explosive Atmospheres (Certification) Regulations 1990 (amended 1999)
- Pressure Systems and Transportable Gas Containers Regulations 1989

Legislation Used in Civil Law

- Occupiers Liability Act 1957 (OLA)
- Occupiers Liability Act 1987
- Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP)
- Electricity at Work Regulations 1989
- Health and Safety (Safety Signs and Signals) Regulations 1996
- The Noise at Work Regulations 1989
- Health and Safety (First Aid) Regulations 1981
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR)
- Health and Safety (Consultation with Employees) Regulations 1996

Appendix F

Guide List of Consultees in England

F.1.1 The following list supplements the guidance provided in Section 2.12 (Stakeholder Consultation and Involvement). The list is not considered to be exhaustive and is given for guidance only. It gives an indication of those who should be involved in the consultation process.

1. Local Highway Authority Area Engineer
2. Adjacent Highway Authorities
3. Local Authority Planning department (if structure is listed or planning or environmental opinion is required)
4. English Heritage (if structure is a Scheduled Ancient Monument)
5. Environment Agency/Internal Drainage Board
6. Borough or District Council
7. Town or Parish Council
8. Statutory Undertakers
9. Navigation Authorities (if necessary)
10. DEFRA (if over tidal water)
11. Public Transport Coordinators
12. Emergency Services
13. Local Authority Traffic Manager
14. Local Council members and MP
15. Chamber of Trade
16. Adjacent and other affected landowner(s)

Appendix G

Process Flowchart for Liaison with Network Rail

G.1.1 The following flowchart supplements the guidance provided in paragraphs 2.13.13 to 2.13.15. The flow chart identifies the key issues that need to be addressed during liaison with Network Rail regarding works that affect the railway and are being initiated by the highway authority.

G.1.2 The process has five initial steps that are common to inspections and works (Table G1). From step six onwards a separate process is used for inspections and works (Tables G2 and G3 respectively).

Table G1 - Initial Steps in Liaison Process	
1	Contact Network Rail Outside Parties section by letter giving details of the job/works and request that they set up a job and appoint a consultant to act as agent on their behalf as appropriate.
2	Wait to be contacted by Network Rail.
3	Hold preliminary site/briefing meeting with Network Rail to discuss scope of works, scheme delivery strategy and likely possession requirements.
4	Network Rail to send through an estimate of their input with engineering conditions.
5	Bridge manager to review engineering conditions and raise an order and letter confirming that the estimated costs are acceptable.

Table G2 - Liaison Process for Inspections	
6	Write to Network Rail requesting that possessions are booked a minimum of 16 weeks prior to required dates. Include method statements and the possession plan for the works, identifying risks, mitigation measures and emergency procedures.
7	Is it accepted?
8	Yes - go to step 9. No – go to step 6 to revise and resubmit.
9	Attend pre-possession meeting on site with COSS (Controller of Site Safety), contractor, site staff, etc.
10	Carry out inspection
11	Confirm completion with Network Rail

Table G3 - Liaison Process for Works	
6	Network Rail will appoint a project manager (PM) in their major projects and investment section (dependent on Territories). Outside Parties section will act as internal client.
7	Hold liaison meetings with Network Rail to discuss works as necessary prior to submitting formal applications for approval. Produce preliminary scheme programme including details of design and works and when possessions are likely. It is important to cover all aspects of the scheme to ensure progress on all aspects. Typical agenda to include technical issues and approvals, possession requirements and programme, H&S, land requirements and works agreement.
7	Submit preliminary programme to Network Rail for comment.
8	Is it accepted?
9	Yes – go to step 10. No – go to step 6 to review and resubmit.
10	Clarify if structure has an existing works agreement, review and modify or initiate new Asset Protection agreement.
11	Commence land negotiations.
12	Submit preliminary application for possessions.
13	Complete Property and Asset Protection agreement.
14	Submit Approval in Principle (AIP) and other details requiring approval, including Her Majesty's Rail Inspectorate (HMRI) approvals.
15	Is it approved?
16	Yes – go to step 17. No - go to 14 to review and resubmit.
17	On award of contract confirm contractors programme and possession requirements, confirm Network Rail's supervision requirements.
18	Hold meeting with Network Rail and contractor to discuss working practices and principles.
19	Contractor submits method statements, temporary works design and supporting information, check certificates, possession programme, etc. to bridge manager for comment.
20	Are they accepted?
21	Yes – go to step 22. No – go to 19 to revise and resubmit.
22	Forward submission to Network Rail for comment/acceptance.
23	Is it approved?
24	Yes – go to step 25. No – go to 22 to revise and resubmit.
25	Hold pre-possession meeting with COSS, ES (Engineering Supervisor), subcontractors, etc.
26	Undertake works
27	Confirm handover/record requirements as necessary.

Appendix H

Process for Dealing with Developer Promoted Structures

H.1.1 The following process for dealing with the Technical Approval of developer promoted structures supports the guidance in paragraphs 2.13.22 to 2.13.26.

1. Appropriate parties within an authority and its agents should inform the bridge manager of all potential developer promoted highway schemes where structures may be involved. This may require the bridge manager to initiate contact with these parties to check that:
 - a. They have the bridge manager's contact details; and
 - b. They have an appropriate process in place to alert the bridge manager when developer promoted schemes affect highway structures.
2. The bridge manager should check that references to the required Technical Approval (TA) procedures are referred to in the schedules to the Section 278 or 38 agreements for the proposed scheme. This will ensure that the developer is aware of the processes involved in TA prior to financial agreement.
3. The bridge manager should check that adequate provision is made in the agreement for commuted maintenance sums and highway authority costs, if this is appropriate. It should also include the time scales for the stages of Technical Approval. A certification process, including certification of construction, should be specified to ensure compliance before formal adoption and release of bonds.
4. Suitably qualified and experienced bridge engineers should be stipulated in the agreement for the design of all structures and the Approval in Principle (AIP) and certification preparation.
5. An initial consultation meeting, attended by the bridge manager and the developer's representatives, should be convened to discuss potential options. Whole life cost solutions should be requested and commuted sums for future maintenance.
6. Processes for TA and treatment of departures from standard should be reiterated.
7. Initial draft of AIP form should be submitted to the Technical Approval Authority (TAA) for comment.
8. TAA, as appointed by the bridge manager, should review draft documents and respond with comments.
9. Resubmit and review as necessary.

10. Developer to submit final original signed copies for countersignature upon acceptance by the TAA.
11. TAA to counter sign agreed AIP document. Retain one copy and return one copy to developer.
12. Developer's designer/checker to progress with design and check.
13. Developer's designer/checker to submit design and check certificates.
14. TAA to review construction drawings and audit as stated in Section 278 or 38 agreements.
15. TAA or bridge manager to audit construction as stated in agreement.
16. Developer's contractor and Works Examiner to certificate construction.
17. Developer to pay commuted sum and other costs to the highway authority if required by the agreement.
18. Handover inspection undertaken by bridge manager if the structure is to be maintained by the highway authority (see Section 6.4 on Acceptance Inspections).
19. Health and Safety file, maintenance manual and "as-built" drawings to be submitted by developer in an agreed format before the road is adopted if the structure is to be maintained by the highway authority (see Section 6.4 on Acceptance Inspection).
20. All remedial work undertaken prior to release of Section 278 or 38 bond.

Appendix I

Summary of Maintenance Techniques

Masonry

- I.1.1 Masonry structures mainly suffer from the deterioration of mortar and therefore the most common maintenance technique involves the re-pointing of the mortar between the bricks or stones. If the loss of mortar is deep, it is necessary to employ deep or pressure pointing and in the extreme to use grouting. Grouting can be a difficult operation since the grout tends to flow into the surrounding fill. Specialist advice is required if grouting is proposed. If the deterioration of the mortar is caused by significant water seepage through the masonry, the rear of the masonry should, for preference, be waterproofed. This is generally a difficult and costly operation. As an alternative, some form of rear face drainage can be provided, such as weep pipes with a filter to prevent the loss of fines from the fill.
- I.1.2 Deterioration of the bricks or stones themselves is normally dealt with by replacing the defective elements, although in some cases, where the deterioration is extensive and appearance is not critical, the whole face is covered with sprayed concrete.
- I.1.3 When a masonry structure has deformed or partially collapsed, the only satisfactory option is to rebuild it. However, if the deformation is small it may be possible to strengthen the structure retaining the deformation. In this case it is important to record in the Structure File the extent of the built-in deformation.
- I.1.4 Further guidance on repair techniques and the many ways of strengthening masonry structures is given in *A guide to repair and strengthening of masonry arch bridges* [6], *Masonry Arch Bridges* [7] and *Masonry Arch Bridges: Condition Appraisal and Remedial Treatment* [8].

Concrete

- I.1.5 Concrete structures can suffer from different deterioration mechanisms. It is important therefore to determine the cause of deterioration before deciding what maintenance work is required. *Diagnosis of deterioration in concrete structures* [9] gives guidance on the causes of defects, their evaluation and the development of appropriate remedial action. *BA 35 Inspection and Repair of Concrete Highway Structures* [10] and *Repair of concrete bridges* [11], although a little dated, also provide guidance on the repair of deterioration and damage in concrete structures.

Concrete Repair

- I.1.6 The publication *Repair of Concrete in Highway Bridges – A Practical Guide* [12], details current thinking on best practice to be adopted for concrete repair. Unless such practices are adopted, it is likely that concrete repairs will be only partially effective in minimising future corrosion of embedded reinforcing steel in concrete. Further information on concrete repair materials is provided in *BD 27 Materials for the Repair of Concrete Highway Structures* [13].

- I.1.7 Costs for concrete repair can vary widely depending on the nature of the repair. Minor repairs to delaminated concrete smaller than 0.05m² may be undertaken using hand tools or mechanical breakout and the concrete placed by hand. Moderate and major repairs greater than 0.05m² generally require breakout at greater depths using a mechanical breaker or water jetting. The repair often requires shuttering and high performance proprietary superflowable concrete. Additional reinforcing bars are often bonded into the repair to account for section losses due to reinforcement corrosion. Alternatively for deck soffits, repairs with light reinforcement and sprayed concrete may be appropriate.
- I.1.8 The size of each individual concrete repair that can be undertaken is dependent upon the assessed capacity of the element with the concrete broken out. The use of temporary support systems may be required to support the structure and/or to allow the free flow of traffic during major maintenance works. Consideration should be given to the effects of trafficking during work and curing and appropriate protective action taken.

Electrochemical Repair

- I.1.9 Electrochemical repair methods such as cathodic protection (CP) or chloride extraction (CE) may be used to arrest the corrosion process. Both CP and CE require an active circuit to be established which forces the steel reinforcement cage to become cathodic (non-corroding) by providing an external anode (corroding). Impressed current CP uses a permanent external anode connected to an electrical supply to ensure cathodic protection. A passive CP system uses a metal anode (such as zinc) with a higher natural galvanic potential than that of steel in order to establish the necessary drive voltage.
- I.1.10 CE is similar to impressed current CP in that an external electricity supply is required to drive the process. However, an anode is supplied as a series of surface mounted panels containing an electrolyte. The drive voltage for CE is very much higher than CP as the aim is to draw the negative chloride ions away from the reinforcement towards the anode and out of the concrete.
- I.1.11 Both CP and CE may require some initial minor concrete replacement repairs to any areas which are delaminated, since the current path is inhibited by cracked concrete. An additional requirement of the specification for concrete repairs where CP is to be used is that the resistivity of the concrete must be kept low such that an electrical current can be passed through it.
- I.1.12 An advantage of electrochemical repair methods is that those areas of concrete contaminated with chloride do not require breaking out. Significant cost savings can result which more than offset the cost of the system installation. Cathodic protection is an active corrosion control method and must be monitored to ensure effective operation. There are a number of anode systems currently available and the technology continues to develop. Further information on cathodic protection is available from *BA 83 Cathodic Protection for Use in Reinforced Concrete Highway Structures* [14].
- I.1.13 Other techniques such as electrochemical chloride removal (desalination) for chloride contaminated concrete, and realkalisation for carbonated concrete may also be considered.
- I.1.14 In recent years an alternative impressed current repair technique termed 'electro-osmosis' has been trialled on chloride contaminated concrete (there is

some debate as to whether 'electro-osmosis' is an accurate description of the process which takes place). The process works by drawing moisture away from the reinforcement, thereby increasing the local resistivity and significantly reducing the rate of corrosion.

Protection of Concrete Surfaces

- I.1.15 The use of pore-lining impregnants provides effective protection against the ingress of chlorides. Current practice has been to apply silane to newly constructed concrete elements that are vulnerable to spray from the carriageway and to older structures where chloride levels are within prescribed limits. Further guidance is provided in *BD43 The Impregnation of Reinforced and Prestressed Concrete Highway Structures using Hydrophobic Pore-Lining Impregnants* [15]. The current Highways Agency specification requires the use of monomeric alkyl(isobutyl)-trialkoxo silane. However with the recent updating of *BD43* [15] other materials, particularly variant forms of silanes and siloxanes, may be allowed providing they comply with the tests given in Appendix 2 of *BD43*.
- I.1.16 Surface impregnation is unlikely to have any significant beneficial effect on concrete already moderately or highly contaminated with chlorides and where the reinforcing steel has started to corrode. However, surface impregnation as a proactive preventative measure after the removal of chlorides, e.g. by concrete repair, should be considered as a possible maintenance option.
- I.1.17 Many bridges in the UK, built since the early 1990's, have had silane treatment applied at the time of construction. Bridges constructed prior to this time have been constructed without silane. There is therefore only limited data available on the likely service life of the treatment. There are difficulties in assessing the penetration depth of silane at the time of application and in determining the effective life of silane treatment.
- I.1.18 Carbonation of concrete occurs when carbon dioxide reacts with the cement paste to form carbonates, which have a lower alkalinity than normal concrete. If carbonation reaches the level of the reinforcement, the reduced alkalinity allows disruption of the passive oxide film that normally protects the steel from corroding and corrosion can initiate. In the UK the quality of concrete used in construction and the external environment means that carbonation has rarely been a problem on modern highway structures, although many of the early reinforced concrete structures do suffer from carbonation due to poorer quality concrete and construction techniques. Anti-carbonation coatings should only be applied well before corrosion initiation or after the alkalinity of the concrete has been restored by concrete repair or re-alkalisation. Generally, protective coatings should not be applied to reinforced concrete elements, except in specialised situations where there is particular engineering justification, e.g. where the elements would need to be replaced once they start to deteriorate in order for them to remain effective.
- I.1.19 Corrosion inhibitors may be useful in certain situations, although the evidence for surface applied migrating inhibitors suggests that they may only be effective on poorer grades of concrete. Concrete admixture cast-in inhibitors are more effective, but are currently advocated only in new reinforced concrete construction in particularly aggressive environments where there are additional potential durability problems.

Buried Concrete Box Structures

- I.1.20 Whilst buried concrete box structures suffer from all the common concrete defects, there are some defects which are peculiar to this type of structure. Guidance on these is given in *BA 88 Management of Buried Concrete Box Structures* [16] together with advice on maintenance. Some culverts on watercourses with particularly erosive flow, e.g. in upland areas where gravel and larger stones are swept through the culvert in time of flood, can suffer from erosion of the concrete invert leading to exposure of the reinforcement. When culverts in this situation are being repaired or replaced, it is advisable to provide additional cover (say 15mm) as a sacrificial layer to allow for future erosion.

Steel, Wrought Iron and Cast Iron

Protective Systems

- I.1.21 The most common method of corrosion protection of these materials is by protective coatings, i.e. paint coatings which are sometimes over metallic coatings of zinc or aluminium. The success of this protection depends not only on the type of protective system specified, but also on the surface preparation and the quality control of application. The service life of the system depends in addition upon the local environment. The *Corrosion protection of steel bridges* [17] outlines current thinking on this subject.
- I.1.22 Major maintenance may be considered to be the whole or partial removal of more than 10% of the existing protective system. The time needed between major maintenance of protective systems in highway structures has progressively increased from 12 to 15 years to 20 to 25 years as protective systems have improved. When a generally sound protective system requires overall maintenance, it should be borne in mind that if the work is delayed, the cost of restoring the system to a satisfactory standard may increase rapidly.
- I.1.23 *BD 87 Maintenance Painting of Steelwork* [18] outlines the procedures necessary in order to achieve value for money in maintenance painting. These procedures include pre-specification overall surveys, feasibility trials of proposed methods of surface preparation and proposed paint system and the use of specialist painting inspectors. Although the full procedure is onerous, it is recommended for all major schemes unless the structure is similar to one where the full procedure has been used and the protective system, defects and local environment are the same. The full procedure can also be used to develop generic treatments for minor maintenance work, e.g. repainting of steel parapets in rural areas.
- I.1.24 Breakdown of protective systems can be accelerated because of the presence of some types of poor details found on older structures (see Appendix L). In these cases it is prudent to consider if some of these details can be improved before carrying out maintenance painting. For example:
1. If metal components are subject to leakage through the deck then this may be prevented by repairs to the waterproofing system or by applying a waterproofing system if it is not present.
 2. If metal components are subject to leakage through an expansion joint, then implement a solution that transfers leakage away from the

components, e.g. install appropriate drainage, amend the layout of the existing joint or install a new joint with an appropriate layout.

- I.1.25 If repairs have to be carried out to the metalwork, any replacement components should be detailed according to latest guidance [17] bearing in mind the need to maintain visual appearance.

Protective Enclosures

- I.1.26 An enclosure around steelwork supporting a bridge deck can provide a controlled environment, reducing the rate of breakdown of the protective system. An enclosure system usually comprises a protective shell of a durable material, e.g. glass-reinforced polymer, stainless steel, or aluminium. The principal advantages of providing an enclosure are: cost savings in corrosion protection both at time of construction and in future maintenance; the provision of permanent access for inspection and maintenance with consequent improvements in safety; the reduction and/or elimination of traffic delay costs during inspection and maintenance. Further information on the design of enclosure systems is provided in *BD67 Enclosure of Bridges* [19] and *BA67 Enclosure of Bridges* [20].
- I.1.27 In considering whether to install a protective enclosure on a bridge over a road, it is essential to consider the likelihood of accidental vehicle strikes. The risk of strikes reduces as the headroom with the enclosure installed increases beyond the minimum new construction headroom given in *TD 27 Cross-Sections and Headrooms* [21]. As enclosures are light structures and are easily damaged by strikes, it is recommended that they should not be installed if the resulting headroom is less than that recommended for footbridges (i.e. 5.70 m).

Corrugated Steel Buried Structures

- I.1.28 If regular and adequate inspections are undertaken, the most common form of maintenance is likely to be the refurbishment of protective coatings and pavings. It is preferable to prevent corrosion than to rely on the presence of sacrificial metal. This is particularly true for culverts where erosive flow may lead to rapid deterioration. Further guidance on the maintenance of this type of structure is given in *BA 87 Management of Corrugated Steel Buried Structures* [22].

Advanced Composites

- I.1.29 Bonded external reinforcement may be adopted to enhance the strength of elements that are considered to be under strength. Steel plate bonding has been demonstrated to be an effective strengthening technique. However, concerns regarding the durability of this technique have led to the development of similar techniques using advanced composites. Since these materials are flexible, their use has also been extended to the wrapping of columns to increase their strength under vehicle impact loading. *BD 84 Strengthening of Concrete Bridge Supports under Vehicle Impact using Fibre Reinforced Polymers* [23] provides guidance on the design of such strengthening. *Strengthening concrete structures with fibre composite materials: acceptance, inspection and monitoring* [24] provides guidance for any strengthening schemes using advanced composites.
- I.1.30 Guidance on the repair of advanced composites is given in *Strengthening concrete structures with fibre composite materials: acceptance, inspection and*

monitoring [24] and *Repair and maintenance of FRP structures* [25]. Where the damage is considerable, the replacement of the damaged element is likely to be required.

Expansion Joints, Drainage and Waterproofing

- I.1.31 One of the most serious sources of damage to highway bridges is salty water leaking through defective expansion joints and from poor or blocked drainage systems. Since a defective joint can also be a serious danger to those using the bridge, it should be repaired or replaced as soon as possible. A comprehensive survey of bridge expansion joints has been undertaken by the Transport Research Laboratory and is reported in *Improving the performance of bridge expansion joints: Bridge Deck Expansion Joint Working Group Final Report* [26]. This report concludes: 'Joints should not be selected on initial cost (and extreme movement capacity) only, without regard to future maintenance and renewal costs over the life of the structure'. As a result of this report, guidance on the selection of replacement joints was provided in a *Practical guide to the use of bridge expansion joints - Application Guide AG29* [27].
- I.1.32 To prevent salty water from penetrating downward to the substructure of a bridge, expansion joints should be watertight and there should be continuity with the deck waterproofing system. Both *Water Management for Durable Bridges: TRL Application Guide AG 33* [28] and the *Bridge Detailing Guide* [29] provide guidance. Since expansion joints may leak before the end of their anticipated service life, the provision of suitably located positive drainage measures should be considered in areas where chloride contaminated water is likely to accumulate in order to prevent damage to the bridge. Guidance is provided in *Water Management for Durable Bridges: TRL Application Guide AG 33* [30].
- I.1.33 The majority of modern bridges have had a proprietary deck waterproofing system applied at the time of construction but older bridges often lack waterproofing. Waterproofing keeps water out of the structure and prevents contamination and corrosion initiation. It should always be considered during the refurbishment of decks and installed in accordance with *BD 47 Waterproofing and Surfacing of Concrete Bridge Decks* [31] and *BA 47 Waterproofing and Surfacing of Concrete Bridge Decks* [32].
- I.1.34 The replacement of deck waterproofing on bridges should generally be undertaken in conjunction with road resurfacing in order to minimise traffic disruption and minimise costs. Approved deck waterproofing systems in accordance with *BD 47* [31] and the associated Highway Authorities Product Approval Scheme (HAPAS) may be expected to have a service life in excess of 30 years. A sand asphalt additional protective layer is laid above the waterproofing system to prevent damage during the replacement of the pavement surfacing.

Bearings

- I.1.35 Modern bearings generally have service lives in excess of 30 years whilst the residual service life of most bridges may be considerably more than 30 years. Bearings design should therefore make provision for future inspection and replacement, in particular the provision of adequate access for jacking procedures. The provision of good safe access can reduce future traffic disruption significantly and also minimise future maintenance costs.

- I.1.36 As the cost of the bearings themselves is only a small proportion of the total cost of any replacement scheme, they should be chosen to ensure that the service life is as long as possible with the use of low maintenance materials such as stainless steel.

Scour

- I.1.37 Structures built in watercourses may be prone to scour around their foundations. If the depth of scour becomes significant, the stability of the foundations may be endangered, with a consequent risk of the structure suffering damage or failure. This is particularly likely with older structures, which tend to have fairly shallow spread foundations. There have been a number of cases of significant traffic disruption due to scour induced bridge failures or partial failures. Any suspected or reported scour should therefore be given a high priority for investigation and/or repair, as appropriate.
- I.1.38 The CIRIA *Manual on scour at bridges and other hydraulic structures* [33] provides a comprehensive treatment of scour including useful advice on design of scour protection. The Manual also includes a section on the assessment of existing structures for risk of scour, summarising unpublished work by both the Highways Agency and Network Rail. The Highways Agency plan to publish a standard on this topic while Network Rail currently have *Standard GC/RT5143 Scour and Flooding – Managing the Risk* [34]. *BA 59 Design of Highway Bridges for Hydraulic Action* [35] gives guidance on the design of structures to protect them from the effects of scour and has a number of useful references that can assist the bridge manager.

Tunnels

- I.1.39 Advice on the maintenance of tunnels is given in *BA 72 Maintenance of Tunnels* [36], which, whilst providing essential guidance on the general aspects of organisation and management of maintenance, also gives other sources of more detailed guidance.

Appendix J

Whole Life Costing

Calculation of Whole Life Costs

- J.1.1 A number of important concepts need to be understood when undertaking a Whole Life Costing (WLC) analysis as described below.
- J.1.2 The **cost elements** are those items included in the WLC analysis. The rules for the inclusion and exclusion of costs from the WLC analysis should be defined in order to produce consistent and comparable values. As a general rule all hard costs, e.g. labour, plant and materials, should be included. The inclusion of other costs, such as traffic delay costs, depends on the ability of the organisation to generate reliable costs and whether or not they wish to include them. *BD36 and BA36 Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures* [37 and 38] give advice on the calculation of traffic delay costs.
- J.1.3 The **discount rate** is used to compare costs that occur in different time periods. The discount rate is based on a principle known as ‘time preference’, i.e. £1 now is worth more than £1 at some time in the future. This process can be understood by considering the principle of compound interest. If £1 is invested at an interest rate of r , at the end of year one it would be worth $£(1+r)$, in two years $£(1+r)^2$ and so on. Conversely, £1 received in n years’ time is worth $£1/(1+r)^n$ now. These principles ignore the effect of inflation and assume that £1 has the same real value in each year.
- J.1.4 It is important not to confuse the discount rate with **inflation**. The discount rate is not the inflation rate but is the investment “premium” over and above inflation. Inflation takes into account the persistent increase in the level of consumer prices or the persistent decline in the purchasing power of money. Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking whole life cost analysis, as it has been taken into account in choosing the discount rate. However, inflation indices should be used to increase unit rates to current cost, e.g. if the unit rates were derived 5 years ago, the appropriate inflation indices should be used to increase them to the current cost. The Highways Agency Road Construction Price Index (RCPI) or the Baxter Indices published by the Department of Trade and Industry may be used to alter historical unit rates or scheme costs. If the latter indices are used, it is necessary to use a weighted basket of indices representing the rate being used.
- J.1.5 The **evaluation period** is the period over which the WLC calculation is performed, i.e. the forward period for which arising costs are included in the calculation. The evaluation period can be based on the expected life of the element or structure. However, it is more common for highway structures, which are long life assets, for the evaluation period to be dictated by the discount rate. If a high discount rate is used, the costs are normally assessed over a 30 year period because costs beyond 30 years become negligible. If a low discount rate is used, the period may be extended to 60 years. The current recommendations from HM Treasury [*Green Book, Appraisal and Evaluation in Central Government*, 39] is an appraisal period of 60 years with discount rates of 3.5% for the first 30 years and 3.0% for the remaining 30

years. Extension of the appraisal period beyond 60 years has a negligible influence.

J.1.6 **Net Present Value (NPV)** is the term used to describe the whole life costs when they are discounted to current value. The NPV represents the cost of future maintenance work at their current perceived value.

J.1.7 The NPV for each option or scheme are compared to identify the most cost effective solution. When developing whole life cost estimates, “Optimism Bias” (i.e. the demonstrated systematic tendency for practitioners to under-estimate the costs of projects and works durations) should also be considered to reduce the risk of under-estimating the cost. Taking account of optimism bias reduces the risk of budgetary and programme over-runs in the forward work plan. More information on this can be obtained from *Procedure for Dealing with Optimism Bias in Transport Planning* [40].

J.1.8 Any future cost may be reduced to its NPV by means of the equation:

$$NPV = \frac{S}{(1 + r)^n}$$

Equation 1

where S cost of work in £

r Discount Rate, expressed as a fraction

n year in which the work is carried out assuming current year is year zero

J.1.9 Items to consider when assessing whole life maintenance alternatives are:

1. The assessment period (it is recommended that 30 or 60 years is used)
2. The discount rate and base year for assessment
3. The initial and ongoing maintenance and operational costs of each option
4. Traffic delay and traffic management costs incurred during maintenance works
5. Component service lives and the likely time to action for recurring items

Appendix K

Prioritisation Systems

K.1.1 Currently a number of work prioritisation systems are used by different authorities. Some of these systems are outlined below. Other prioritisation systems that have been used in the construction industry are also highlighted and include multi-criteria and cost-benefit analysis.

K.1.2 It is recommended that the four performance measures described in Section 3.8 are used in any prioritisation method since they generally cover the broad functionality and management of highway structures. However, there may be a need to take account of some other criteria that are deemed relevant to an authority but are not fully covered by the performance measures.

Highways Agency Value Management Process

K.1.3 The Highways Agency has an internal system, which is used by all their maintaining areas, and aims to provide a consistent approach to work prioritisation. The use of a common system allows the Agency to compare the works programmes submitted by the Maintaining Agents and allocate funds accordingly. The comparison is currently only undertaken at a regional level. The system works by deriving a score based on the likelihood and consequence of an accident happening on the network. The likelihood rating is based on cause, defect, exposure and effect categories. This score is combined with the consequence scores for safety, functionality, sustainability and the environment and provides an overall priority indication.

K.1.4 Similar systems are used by the devolved administrations and other maintaining bodies, but are not generally available. They are all based on techniques involving such matters as comparing several different criteria, weighting them, value for money or cost-benefit.

Strengthening Prioritisation based on BA79

K.1.5 *BA79 The Management of Sub-Standard Highway Structures* [41] lists the factors which should be taken into account in any prioritisation of strengthening work. These include:

1. Risk of structure collapsing.
2. Traffic delay costs caused by interim measures.
3. Other social, environmental and economic consequences caused by interim measures.
4. The negotiability of alternative routes.
5. The cost-effectiveness of the strengthening (ratio of costs and benefits).
6. Other benefits from scheme.

K.1.6 Several authorities have developed strengthening prioritisation systems based on these criteria.

LoBEG Prioritisation System

K.1.7 LoBEG (London Bridges Engineering Group) has developed a strengthening prioritisation system, using Multi-Criteria Decision Analysis (see below), based on BA79 and defined the main criteria as:

1. Risk of failure – based on the probability and consequence of failure.
2. Cost of works – the current cost of the scheme and how this is likely to change if the work is delayed.
3. Social impact of bridge restrictions – any undue impact that load restrictions would have on the local community, including aesthetics.
4. Cost of interim measures – the cost of traffic delays caused by interim load restrictions.

K.1.8 The system was developed in collaboration with all 33 London Boroughs and has been successfully used to prioritise bridge strengthening schemes across London. The system was subsequently extended to cover the prioritisation of strengthening and maintenance schemes. To support this change a durability criteria was added to the above list. At the time of publication of this Code, LoBEG were reviewing the prioritisation system against the Condition, Availability and Reliability Performance Indicators.

Multi Criteria Decision Analysis

K.1.9 Multi Criteria Decision Analysis is used to compare the relative importance of multiple criteria and involves the principles of the Analytic Hierarchy Process (AHP) (*Analytic Hierarchy Process* [42] and *Multi Criteria Decision Making: The Analytical Hierarchy Process* [43]). The analysis enables pair-wise comparisons in order to evaluate all the criteria. The output is a relative score that allows the assessment and comparison of different schemes. The development of the system may require expert input from several disciplines to identify the relative importance of key aspects. The modelling process is also able to account for sensitivity and inconsistency, therefore making it more robust.

Cost-Benefit Analysis

K.1.10 Cost-benefit analysis is designed to measure the net social benefit of a scheme by comparing the sum of the benefits generated to the sum of the costs incurred, all discounted to the same date. If the benefits exceed the costs, it is considered that implementing the scheme would generally be advantageous; conversely, if the benefits amount to less than the costs, it may be considered that other schemes would offer increased benefits. Schemes can be ranked on their relative cost-benefits. A full description of the process is given in *Cost-Benefit Analysis for Engineers and Planners* [44]. Such analyses are used by the national highway bodies for the economic assessments of road schemes, e.g. *Economic Assessment of Road Schemes in Scotland* [45].

Appendix L

Undertaking Inspections

- L.1.1 This Appendix gives general advice and guidance on carrying out inspections for different structure types and materials. The level of activity and information acquired should be commensurate with the type of inspection being undertaken.

Masonry Structures

- L.1.2 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, seepage of water through the structure and deterioration of the bricks or stones. Cracking can have a variety of causes including overloading, vibration or impact from traffic, settlement, failure of the foundation, temperature changes or wetting and drying. It may be necessary to initiate a Special Inspection in order to determine the cause of the cracking.
- L.1.3 The inspection should 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* [46].

Concrete Structures

- L.1.4 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.
- L.1.5 Where reinforced concrete retaining walls face onto carriageways, they can become contaminated with chloride from the spray of passing traffic. Retaining walls that 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.
- L.1.6 Where cracking of concrete due to reinforcement corrosion or corrosion of prestressing tendons is suspected, it may be appropriate to carry out some simple testing during a Principal Inspection, such as measurement of chloride content or electrode-potential (half-cell). The results obtained should be recorded in the Structure File for future reference. Further guidance may be obtained from *BA 35 Inspection and Repair of Highway Structures* [47], *BA 88 Management of Buried Concrete Box Structures* [48] and *Diagnosis of Deterioration in Concrete* [49].

- L.1.7 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* [50].
- L.1.8 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 at risk of loss of prestress.
- L.1.9 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 Post-tensioned bridges; Planning, organisation and methods for carrying out Special Inspections* [51]. 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 large influence on its vulnerability to tendon corrosion.

Steel Structures

- L.1.10 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. 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.
- L.1.11 The steelwork in some structures, particularly bridges, has been enclosed to reduce the rate of corrosion. Such enclosures should be inspected during all General and Principal Inspections of the structure. Although enclosures should have a long service life, some components or seals may have short lives [*BA 67 Enclosure of Bridges*; 52].
- L.1.12 Older bridges may be at risk of fatigue-induced failures, although fatigue susceptible details may also be present on more recent bridges. Fatigue failures may arise particularly where:
1. The bridge was not designed for fatigue.
 2. The bridge was designed to inadequate fatigue criteria, or where materials and manufacturing, or fabrication controls were not adequate.
 3. Operational or structural changes have occurred.
 4. There is evidence of resonance occurring in any of the structural members.

- L.1.13 Weathering steel is a special type of steel which is usually allowed to corrode, because it corrodes very slowly and forms a protective (oxide) patina. Weathering steel sections cater for the loss of thickness due to slow rusting during the life of the bridge by providing an extra thickness in addition to the minimum design thickness required for structural purposes. They are particularly vulnerable in wet/dry situations and at web flange joints, where settled rust deposits may retain water like a sponge. Where structures contain such material, the owner should follow the procedures given in *BD 7 Weathering steel for highway structures* [53].
- L.1.14 Structures that have been strengthened using externally bonded plates, require inspections to check that the strengthening is functioning as intended and that the plates are not becoming detached.
- L.1.15 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 structures 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. Advice on the inspection of these structures is given in *BA 87 Management of corrugated steel buried structures* [54].
- L.1.16 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 NDT techniques. Bolts and rivets should be checked to establish that none are loose or missing.
- L.1.17 Older structures often have details which are susceptible to corrosion, so inspectors should give particular attention to areas such as:
1. Small gaps between components which are not adequately sealed.
 2. Where components are built into concrete or masonry.
 3. Water traps and areas where debris can build up.
 4. 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 Principal Inspection.
 5. Areas subject to leakage of de-icing salts, e.g. members below deck joints, joints in trough or plate decking.

Cast Iron and Wrought Iron Structures

- L.1.18 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.

- L.1.19 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.
- L.1.20 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.
- L.1.21 The only certain method for distinguishing between wrought iron, cast iron and steel is 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. These are described in *Appraisal of Existing Iron and Steel Structures* [55].
- L.1.22 Corrosion of wrought iron is relatively slow but it may reach significant proportions because of the age of the structure. 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.
- L.1.23 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.

Advanced Composites Structures

- L.1.24 Advanced composites such as FRP have been used in highway structures since the 1970's, mainly within soil-reinforcement systems. Another common application is the use of glass fibre reinforced panels as permanent soffit formwork spanning between deck beams. Since 1990 advanced composites have been used as structural elements in bridges, including footbridges, and as bridge enclosure systems. They are also used in repair applications, where thin plates, usually of carbon fibre, are bonded onto existing structures to provide extra strength.
- L.1.25 The surface of the composite 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 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 [56] and *Repair and maintenance of FRP structures* [57].

Timber Structures

- L.1.26 The main problems for timber structures/elements are decay, insect attack, splitting and separation of laminated layers.
- L.1.27 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.
- L.1.28 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.
- L.1.29 Insect attack can 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 many larger holes, the problem is serious.
- L.1.30 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.
- L.1.31 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:
1. Splits across the grain of the wood.
 2. Splits orientated so that water can accumulate in them.
 3. Splits around connections such as bolt holes.
 4. Splits that are observed to be increasing in size.
- L.1.32 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.
- L.1.33 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.

Retaining Walls

- L.1.34 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. 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.
- L.1.35 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.
- L.1.36 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.

Gantries and Cantilever Sign Structures

- L.1.37 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.
- L.1.38 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.
- L.1.39 Particular care should be given to looking for 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.

Tunnels

- L.1.40 The authority should follow the requirements for the inspection of road tunnels given in *BD 53 Inspection and records for road tunnels* [58] together with *Procedures required for assessing highway structures - working group 2 & 3 - methods used in European states to inspect and assess the condition of highway structure* [59] which applies to road tunnels longer than 500m on the trans European network. The inspection categories are the same as for other highway structures but special attention should be given to the requirements for the inspection of the mechanical and electrical equipment (M&E) of the tunnel. This equipment should receive a General Inspection every year and a Principal Inspection every three years. *BA 72 Maintenance of Road Tunnels* [60] and *BD 78 Design of Road Tunnels* [61] also provide guidance on aspects of inspections/maintenance.
- L.1.41 The Principal Inspection may require removal of cladding, casings and mountings to fans, etc. in order to gain access. In many cases special testing and access equipment may be required and it may be necessary to employ

specialist firms. An emergency exercise involving relevant emergency services should be undertaken as part of the M&E inspection.

- L.1.42 Acceptance Inspections (of the Principal type) are required at handover of a new or existing road tunnel. There are two classes of Acceptance Inspection: for new road tunnels (including refurbishment of existing tunnels) and for existing road tunnels. These inspections are described in *BD 53* [58].
- L.1.43 The Tunnel Operating Authority (TOA) is required to keep and update records for all road tunnels for which it is responsible. A complete list of the required records, with their distribution, is given in *BD 53* [58].

Appendix M

Selection of Test Houses and Specification and Procurement of Testing

Selection of Test Houses

- M.1.1 Specialised test houses often undertake the inspection, testing and monitoring of highway structures. Some also carry out deterioration modelling, whilst others merely provide the data to the engineer for them to do the modelling. They should be approved by the authority and have an acceptable quality assurance system. They should have an established reputation for carrying out structures testing, and be able to show a track record of experience in using the intended equipment with an operator experienced in interpreting the results in relation to the type of structure under investigation and the application.
- M.1.2 Details of testing organisations can be obtained from a variety of sources including the British Institute of Non-Destructive Testing (www.bindt.org).
- M.1.3 The testing organisation should have an acceptable Health and Safety record, in particular related to working at height, working under COSHH regulations, working adjacent to live traffic, working with mobile elevated working platforms, working with electrical equipment and, where applicable, working in/over water or under railway safety requirements.
- M.1.4 The testing organisation should be required to demonstrate it has carried out a Health and Safety Risk Assessment, and taken appropriate action before starting work, and prior to any additional work instructed during the contract which extends the areas of investigation.
- M.1.5 Sampling and testing should be carried out by testing firms or laboratories fulfilling the relevant requirements of the authority. These organisations are generally those operating recognised quality assurance procedures for the relevant tests, such as those in accordance with *BS EN ISO 9000 Quality management systems* [62] or the United Kingdom Accreditation System (UKAS).
- M.1.6 Where specialised tests are required, the work is sometimes undertaken by universities or research organisations with expertise in the particular test being used. Although this work is usually done on a trial basis (i.e. to determine the effectiveness of the technique, its applicability on site and whether further development is required) the results may still be useful.

Specification for Structures Testing

- M.1.7 Advice on specifying structures testing and on evaluating tenders can be obtained from *BA 86 Advice Notes on Non-Destructive Testing of Highway Structures* [63]. The work on site should be supervised and the operator interviewed so they can demonstrate their competence. Additional tests may be required in order to determine the extent of structural features or faults. It is often important for the work to be staged so that later tests are targeted to determine more detailed information about features identified in earlier tests.

- M.1.8 Traffic management costs can account for a considerable proportion of the total contract value. These costs can be uncertain because traffic management is often provided by sub-contractors, is supplied during a shorter tender period and is usually for work in unfamiliar locations. An alternative approach is to separate traffic management costs from the cost of testing and to tender purely on the basis of testing. The successful tenderer can then select the most cost effective traffic management scheme by using local contractors or the authority's in-house or term contractor. Where possible, testing should be programmed to coincide with other work on the network in order to minimise traffic management costs and disruption to the network.

Procurement of Structures Testing

- M.1.9 Testing is generally procured by competitive tendering and a variety of forms of contract are used. Satisfactory contracts depend upon effective presentation of the requirements. To encourage testing contractors to deliver quality there is an increasing trend towards judging tenders on the basis of both cost and quality, whereby the quality bids are opened first and only bids of acceptable quality have their cost envelopes opened. The contract may be awarded by comparing the costs of those that passed the quality test and then giving it to the bidder with the lowest cost.
- M.1.10 Sometimes the contract is awarded on the basis of marks given for both cost and quality. Quality marks are awarded for the experience of the test house (for that particular type of test) and the methodology adopted. Account may also be taken of the health and safety record of tenderers. Cost marks are based not only on the overall cost but also on the cost of any additional work required and the allocation of resources to interpretation and reporting. The final mark is based on a combination of the marks awarded for quality and cost, although these costs may not necessarily be given equal weight. If the authority is prepared to place a premium on quality, the marks may be weighted 60/40 or 70/30 in favour of quality.

Appendix N

Abnormal Load Categories

- N.1.1 A summary is given below of the rules defining the various abnormal load categories as they typically affect the management of bridges and other highway structures. The information given has been significantly simplified and, where appropriate, detailed reference should be made to the relevant Statutory Instruments.
- N.1.2 Normal traffic, which travels without any special requirements is primarily defined in:
1. *The Road Vehicles (Construction and Use) Regulations 1986 (C&U Regulations)* [64].
 2. *The Road Vehicles (Authorised Weight) Regulations 1998 (AW Regulations)* [65].
 3. *The Road Vehicles (Authorised Weight) (Amendment) Regulations 2000* [66]
- N.1.3 General Order Vehicles are defined by *The Road Vehicles (Authorisation of Special Types) (General) Order 2003 (STGO Regulations)* [67].
- N.1.4 Special Order Vehicles include those which do not comply with either the Authorised Weight Regulations or the STGO Regulations.
- N.1.5 The C&U Regulations limit vehicle weights and widths to 38 tonne and 2.9 m respectively. The Regulations also define limits on wheel and axle loading and spacing configurations, together with various limits on all vehicle lengths.
- N.1.6 The AW Regulations increased the maximum gross weight to 40 tonnes or 44 tonnes depending on the number and weights of their axles.
- N.1.7 The STGO Regulations define three categories of General Order vehicle:
1. Category 1 has a maximum weight limit of 46 tonnes. In all other respects it conforms to the AW limits of axle load and configuration.
 2. Category 2 has a maximum gross vehicle weight (GVW) limit of 80 tonnes and maximum axle weights of 12.5 tonnes, subject to axle spacing limitations.
 3. Category 3 has a maximum gross weight limit of 150 tonnes and maximum axle weights of 16.5 tonnes, subject to axle spacing limitations.
- N.1.8 All three categories are subject to the following dimensional limits:
1. Authority from relevant governing body (VR1) needed when widths exceed 5 m.
 2. Maximum width 6.1 m.
 3. Maximum length 30 m.

N.1.9 Vehicles with weights or dimensions exceeding those given above must travel as Special Order Vehicles. Applications for Special Orders must be made to the Highways Agency's Abnormal Indivisible Loads (AIL) Team for movements in England, Scotland and Wales; and to the Roads Service Headquarters, Network Development Branch for movements in Northern Ireland.

N.1.10 Notifications that have to be provided by hauliers for moving both STGO and Special Order Vehicles are summarised in Table N.1.

Table N.1 - Notification Requirements for STGO Vehicles		
Suggested Classification	Limiting Characteristics	Notice Required
WdA	Width exceeding 3.0m but up to and including 5.0m	Two clear working days notice to relevant Police Authority. Also to highway and bridge authorities with indemnity certificate, if vehicle exceeds weight limits (see below)
WdB	Width exceeding 5.0m but up to and including 6.1m	10 days notice to Highways Agency and VR1 and Two clear working days notice to relevant Police Authority. Also to highway and bridge authorities, with indemnity certificate, if vehicle exceeds weight limits (see below)
WdC	Width exceeding 6.1m	Special Order Vehicle - eight weeks notice to Highways Agency, and five clear working days notice to Police Authority and five clear working days to highway and bridge authorities with indemnity certificate
LgA	Length exceeding 18.75m but up to and including 30.0m	Two clear working days notice to relevant Police Authority. Also to highway and bridge authorities, with indemnity certificate, if vehicle exceeds weight limits (see below)
LgB	Length exceeding 30.0m	Special Order Vehicle - eight weeks notice to Highways Agency, and five clear working days to Police Authority and five clear working days, with indemnity certificate, to highway and bridge authorities
WtA	GVW exceeding C&U or AW limits but up to and including 80 tonnes.	Two clear working days notice, with indemnity certificate, to highway and bridge authorities
WtB	GVW exceeding 80 tonnes but up to and including 150 tonnes	Two clear working days notice to relevant Police Authority and five clear working days notice, with indemnity certificate, to highway and bridge authorities
WtC	GVW exceeding 150 tonnes	Special Order Vehicle - eight weeks notice to Highways Agency and five clear working days to Police Authority and five days to highways and bridge authorities with indemnity certificate

Refer to Table 8.1, in Section 8.6, for definitions of WdA, WdB, WdC, LgA, LgB, WtA, WtB and WtC.

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