Task No: YY86731

Guidance Document for Performance Measurement of Highway Structures

Part C: Measuring the Structures Backlog

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1. Introduction

1.1 Structures Backlog Definition

The Structures Backlog is defined as (Ref. 1):

> *The monetary value of work required to close the gap between the actual performance provided by an asset and the current required performance.*

1.2 Background, Objectives and Scope

The background, objectives and scope are discussed in *Part A: Framework for Performance Measurement*.

2. Proposed Approach

2.1 General

The following is a proposed approach for calculating the monetary value of the Structures Backlog. It is recommended that a computerised Bridge Management System (BMS) is used to calculate the backlog as it is not efficient to perform the calculation manually. This approach aligns with the Asset Management Planning process described in the Code of Practice (Ref. 1)

2.2 Performance Measures and Targets

In accordance with the Code of Practice (Ref. 1), backlog is defined as *The monetary value of work required to close the gap between the actual performance provided by an asset and the current required performance*. As such, an appropriate suite of Performance Measures are required to:

- Describe the current performance of the structure stock; and
- Describe the Performance Targets for the structure stock.

It is recommended that the Condition, Availability, Reliability Performance Indicator and suitable local indicators, are used to define the current performance and the Performance Targets.

2.3 Structures Backlog Scale

The Structures Backlog is expressed in pounds. Thus a set scale, such as that used for the Condition, Availability and Reliability PIs, is not appropriate. However, time vs. backlog profiles can be used to indicate if funded is set at an appropriate level, i.e. is the backlog increasing, decreasing or steady state over a period of time.

2.4 Structures Backlog Score

The Structures Backlog is the cumulative cost, in pounds, of the work required on the structure stock to close the gap between the current performance and the Performance Targets. If there is no gap between the current performance and the Performance Targets then the Structures Backlog is zero.

In order to compare the backlog evaluated in different years it is important to index historical backlog values. Section 4.2 provides details of how indexation should be applied to the Structures Backlog.

2.5 Steps for evaluating the Structures Backlog

An overview of the proposed approach for calculating the Structures Backlog is shown in Figure 1; the following summarise each step. It should be noted that the majority of the boxes in Figure 1 align with the Asset Management Planning process from the Code of Practice (Ref. 1).

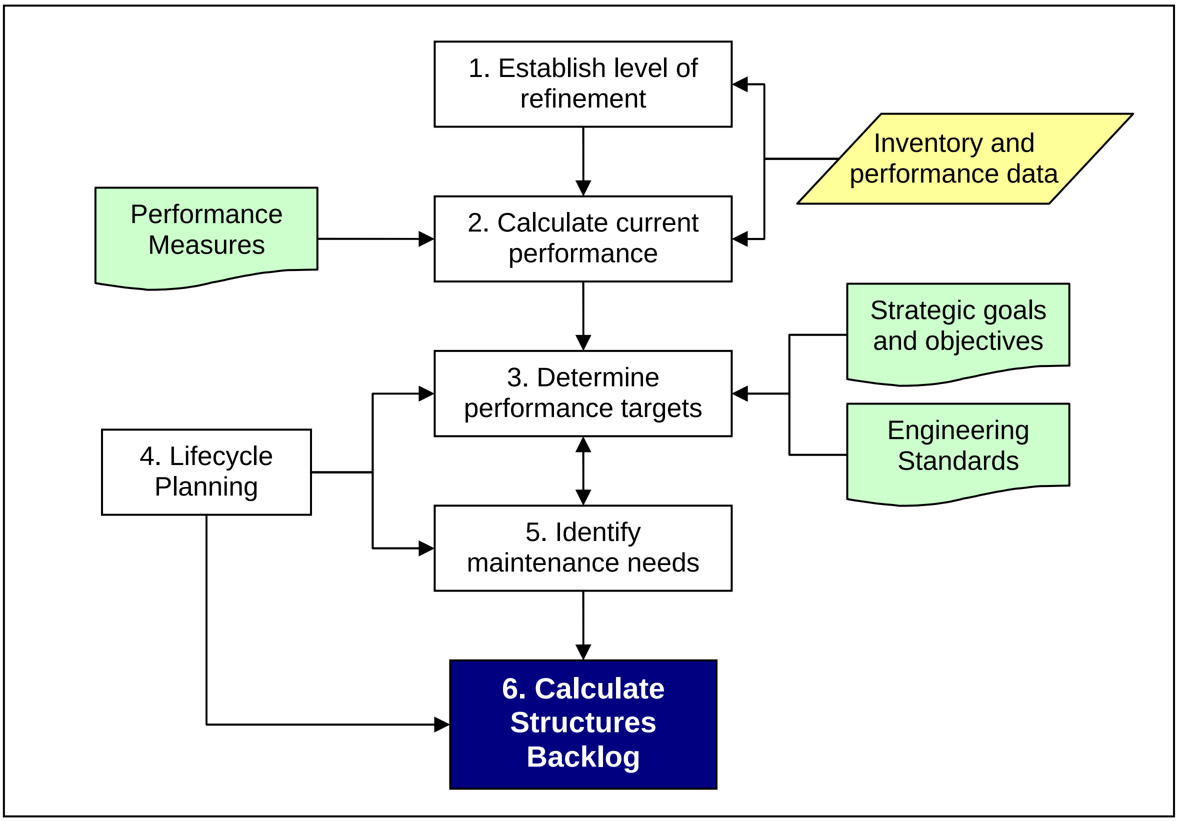

Figure 1 Flowchart of Structures Backlog evaluation procedure

Step 1 – Establish level of refinement

The approach for calculating the Structures Backlog is relatively straightforward; however the effort involved in performing the calculation depends on the level of refinement adopted. For example, Table 1 shows how the level of refinement may differ between a *Basic* and an *Advanced* approach.

Table 1 Level of Refinement

Criteria	Basic	Advanced
Calculations	Are based on generic groups of structures, e.g. concrete, masonry and metal bridges	Are based on specific elements, e.g. parapets on bridge x, abutments on bridge y
Performance Measures	Use the Condition Performance Indicator	Use the Condition, Availability and Reliability PIs, plus local PIs
Performance Targets	Targets based on engineering judgement	Targets derived from strategic goals, lifecycle plans and "what-if" analysis
Unit Rates	Are based on inspector and/or engineering experience and judgement	Are based on contract rates and final scheme outturn costs and take account of influencing criteria, e.g. access and traffic management.

An authority should identify the level of refinement that best suits their asset information, BMS functionality and resource availability. The level of refinement adopted should be fully documented in order to ensure repeatability of the exercise and continuity between consecutive calculations. It may be prudent to first adopt the *Basic* approach and then progress towards an *Advanced* approach in parallel with the development of improved asset management practices.

Step 2 – Calculate current performance

The Performance Measures selected in Step 1 should be used to calculate the current performance of the structures stock.

Step 3 – Determine performance targets

The Performance Targets should take account of the authority's strategic goals and objectives (see Section 3 of the Code of Practice, Ref. 1) and any relevant engineering standards, for example:

- *Strategic Goals and Objectives* – if a strategic objective is to maintain the highway network in a "Good State of Repair", then the bridge manager may interpret this as maintaining a Condition PI score for the structure stock of 85 or greater.

- *Engineering Standards* – the requirement to cater for 40 tonne vehicles may be interpreted by setting an Availability PI target of 100.

The Performance Targets should also be informed by the management policies and strategies, particularly the Lifecycle Plans (see Step 4).

Step 4 – Lifecycle Planning

Sections 3 and 5 of the Code of Practice (Ref. 1) provide guidance on developing Lifecycle Plans. A Lifecycle Plan is defined as is *a long-term strategy for managing an asset, or group of similar assets, with the aim of providing the required levels of performance while minimising whole life costs* (Ref. 1).

The Lifecycle Plan determines the maintenance intervention thresholds thereby influencing the overall Performance Targets (see Step 3). For example, consider the Condition PI scores that would be produced by the following Lifecycle Plans:

- Lifecycle Plan 1 – identifies that a preventative maintenance strategy is more economic for a particular group of reinforced concrete bridges, e.g. cathodic protection and silane impregnation.

- Lifecycle Plan 2 – identifies that a reactive maintenance strategy is more economic for a particular group of masonry arch bridges, e.g. undertake moderate masonry repairs when they are identified.

Lifecycle Plan 1 would in general produce a higher Condition PI score for the group of structures than Lifecycle Plan 2 because maintenance mitigation and/or intervention occur at an earlier stage of the deterioration process. As such, this should be reflected in the PI target.

The key information provided by a Lifecycle Plan is:

- The frequency of a maintenance activity and/or the condition/performance threshold that triggers the maintenance activity.
- The type of maintenance activities used on the structure/component.
- The units cost of the maintenance activity.
- Factors that account for influences on the unit cost, e.g. traffic management, access etc.
- Algorithms that calculate the overall cost of an item of maintenance work, taking account of the unit rate, any influencing factors and the characteristics (dimensions) of the component, structure or group of structures.

A database of maintenance unit rates and influencing factors should be compiled and continually updated. Section 4.3 provides further guidance on unit rates and maintenance cost algorithms.

Step 5 – Identify maintenance needs

The maintenance needs that contribute to the Structures Backlog are all those works that have passed the intervention threshold. Examples would include (also see Section 4.4):

- Overdue inspections.
- Overdue routine maintenance
- Life expired components, e.g. bearings and expansion joints.
- Components that have passed the condition intervention threshold specified in their lifecycle plan, e.g. a lifecycle plan may require moderate concrete repairs to intervene before or at condition 3B, therefore, if the condition of the element passes condition 3B the work is classified as a backlog.
- Structures/components that have substandard performance, e.g. load carrying capacity less than 40 tonne.

It is important that asset information is kept up-to-date; otherwise the identified maintenance needs may include previously completed work. The details of how an authority identifies completed work and removes it from their database will depend on systems/procedures they have in place. This is best achieved through computerised systems where work actions can be readily tracked, via unique identifiers, and *closed out* or *signed-off* when the work is completed.

Step 6 – Calculate structures backlog

The costs of the maintenance identified in Step 5 are calculated using the unit costs, influencing factors and algorithms developed under Step 4. The cumulative cost of these maintenance needs is the Structures Backlog.

3. Data Requirements

The data requirements for the Structures Backlog are shown in Table 2.

Table 2 Data Requirements

Data	Classification
Asset inventory, condition and performance information commensurate with the refinement of the approach adopted (the condition and performance information should be dated*)	Essential
Details of completed work including the date they were completed (so they are excluded form the backlog calculation)	Essential
Maintenance unit rates	Essential

* the dates relating to the condition/performance information are essential if an authority wishes to produce profiles of how the backlog is changing over time.

4. Calculating the Structures Backlog

4.1 General

Further guidance on certain aspects of the backlog calculation are provided in the following, including:

- Indexation of costs, Section 4.2
- Maintenance Costs, Section 4.3
- Work type definitions, Section 4.4

4.2 Indexation of Costs

Performance Measures are beneficial when used to monitor trends over time. However, the monetary value of maintenance work changes over time due to inflation and other influencing factors, therefore to enable meaningful comparisons over time it is important to account for these influences in the Structures Backlog. An index is used to account for these factors as shown in Equation 4. An authority should consistently apply the index that is most suitable for their construction projects, e.g. Baxter Index, Road Construction Price Index or Road Construction Tender Price Index.

$$C_{Y1} = \frac{C_{Y0} \times Index_{Y1}}{Index_{Y0}}$$

Equation 1

Where C_{Y1} = value of backlog adjusted to current year

C_{Y0} = value of backlog from original estimation year

$Index_{Y0}$ = Index for original year

$Index_{Y1}$ = Index for current year

The monetary value of previous calculated backlogs can then be adjusted for direct comparison with the current backlog, thus allowing meaningful time profiles to be developed.

4.3 Maintenance Costs

To provide consistency in backlog calculations (i.e. year on year comparability and comparability between authorities), the maintenance costs should include:

1. Direct Costs (labour, plant and materials).
2. Preliminaries, e.g. site prep, access etc.

3. Traffic management.

4. STATS, e.g. gas, electric, telephone etc.

5. Other – included to cover other criteria that the inspector/engineer may feel is particularly relevant to this work activity.

The format of the algorithm used to calculate the maintenance cost will depend on the structure/component type, type of maintenance and the site characteristics, e.g. access requirements. However, the maintenance cost for an identified need would normally take the following form:

$$C = f(UR, Dim, Def, AD)$$

Equation 2

Where

C - maintenance cost

UR - unit rate

Dim - dimensions of structure/component, used to scale the base unit rate

Def - defect rating, used to scale the base unit rate, i.e. extent of damage

AD - factor/s to take account of additional costs, e.g. access

It is recommended that neighbouring authorities work together to establish a set of generic unit costs and algorithms in order to share the workload and provide comparability. It should be noted that the same maintenance unit rates and algorithms are required for long-term asset management planning (Ref. 1) and asset valuation (Ref. 2).

The cost of work required to improve the condition/performance of a structure will depend on the condition/performance that the engineer wishes to achieve after the work is complete. The condition/performance sought after work may not always be the as-built condition or full performance. If the most appropriate action for the structure is not to regain as-built condition or full performance then this should be reflected in the cost included in the backlog.

4.4 Maintenance Types

The Structures Backlog should include all overdue maintenance. Table 3 provides guidance on when a certain maintenance type may be included in the backlog. The maintenance types presented in Table 3 align with the categories and types provided in Section 5 of the Code of Practice (Ref. 1).

Table 3 Work Types

Maintenance Category	Maintenance Type	What to include in the backlog?
Regular Maintenance	Inspections	Any inspection (General, Principal or Special) that has passed its scheduled year
	Structural Reviews and Assessments	Any structural review or assessment that has passed its scheduled date or has not been carried out after the need was identified
	Routine Maintenance	Any routine maintenance scheduled for the past 12 months that has not been carried out
	Management of Substandard Structures	The cost of appropriate interim measures for any structure that is classified as substandard but currently has no interim measures in place
Programmed Maintenance	Preventative Maintenance	Any preventative maintenance that has passed the time/condition of application, e.g. painting, cathodic protection, minor repairs
	Component Renewal	Any renewable component (e.g. bearings and expansion joints) that has passed the time/condition of renewal
	Upgrading	Any work required to bring a structure up to the authority's required standard, e.g. strengthening, waterproofing, parapet upgrade
	Widening and Headroom Improvements	Any work required to bring a structure up to the route requirements (provided it is deemed as being below the performance required by the authority)
Reactive Maintenance	Emergency	Not applicable - any work deemed as emergency should be dealt with immediately
	Essential Maintenance	Should already be covered by the regular and programmed maintenance categories, i.e. a defect or damage needs to pass the regular or programmed maintenance thresholds before it can be classified as essential

5. References

1. Management of Highway Structures: A Code of Practice, Department for Transport, TSO, September 2005.

2. Guidance Document for Highway Infrastructure Asset Valuation, Roads Liaison Group, TSO, July 2005.