VOLUME 3 **HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE**

SECTION 4 **ASSESSMENT**

PART 18

BA 79/98

THE MANAGEMENT OF SUB-STANDARD HIGHWAY STRUCTURES

SUMMARY

This Advice Note is intended to provide guidance on the interim safety measures appropriate for sub-standard structures.

INSTRUCTIONS FOR USE

This is a new document to be inserted in to the manual.

1. Insert BA79/98 into Volume 3 Section 4.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

The Management of Sub-standard Highway Structures

Summary: This Advice Note is intended to provide guidance on the interim safety measures appropriate for sub-standard structures.

Volume 3 home page

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend	Page No No	Signature & Date of incorporation of amendments

Volume 3 home page

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend	Page No No	Signature & Date of incorporation of amendments

VOLUME 3 HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE

SECTION 4 ASSESSMENT

PART 18

BA 79/98

THE MANAGEMENT OF SUB-STANDARD HIGHWAY STRUCTURES

Contents

1. INTRODUCTION

General

1.1 Departmental Standard BD 21 contains the requirements for assessment and strengthening of highway bridges and other structures. The associated standards BD 34, BD 46 and BD 50 provide further requirements for the three stages of the current trunk road assessment and strengthening programme. BD 21 also stipulates the requirements for interim actions necessary for structures assessed to be inadequate, until they can be strengthened. In practice it has been found by highway authorities that strict application of the BD 21 recommended interim measures would, on many occasions, have led to considerable traffic disruption and other expenditure out of proportion with the perceived risk, and have in such cases departed from the standard. The purpose of this Advice Note is to clarify where departures from the BD 21 interim measures may be considered appropriate and provide a procedure so that such departures are used consistently and with proper records.

1.2 The current Bridge Assessment and Strengthening programme is nearing its target completion date of 1 January 1999. In due course therefore, BD 34, BD 46 and BD 50, which implemented the programme, will become obsolete although much of the advice relating to bridge assessment contained in those standards will still be required for future on-going work. It is intended that this Advice Note will provide guidance beyond the current programme and will be applicable to future cyclical assessments within maintenance management programmes.

1.3 The choice of appropriate interim measures for structures assessed to be inadequate has a direct bearing on the amounts and timing of the maintenance bids concerning those structures. This Advice Note is intended to provide a consistent basis for such bids in future.

1.4 This Advice Note has been prepared by a working group consisting of representatives from the following bridge authorities:

The Highways Agency
The Scottish Office
The Welsh Office
Department of the Environment for Northern Ireland
Local Authorities represented by CSS (formerly County Surveyors Society)
British Waterways
Railtrack PLC.

The membership also included a number of consulting engineers, safety experts and the Transport Research Laboratory.

1.5 Although this Advice Note is primarily intended for use by the Overseeing Organisations, the above committee recommends that the advice provided herein should also be used by other highway authorities and private bridge owners for managing their structures so that a national operational standard is maintained in respect of structural adequacy. Its application to particular assessments should be confirmed with the Technical Approval Authority (TAA).

Scope

1.6 This Advice Note covers the safe management of highway structures which are found to be sub-standard during or following an assessment. It covers bridges, retaining walls and other highway structures and their structural components such as piers, foundations and abutments. In particular the Advice Note provides guidance on the following topics:

Definitions of sub-standard structures

Assessment process

Interim measures during assessment

Interim measures after assessment pending strengthening

Monitoring

Prioritisation for strengthening

Implementation

1.7 This Advice Note shall be used forthwith for trunk road structures being assessed or found to be Sub-standard.

Definitions

1.8 The following definitions apply to certain terms used in this Advice Note:

Sub-standard Structures. Structures found to be inadequate in terms of meeting the loading requirements and principles given in BD 21, after carrying out as rigorous an assessment as considered appropriate by the Technical Approval Authority (TAA). For retaining walls, not all assessments will be calculation based.

Provisionally Sub-standard Structures. If a structure is assessed to be inadequate at any stage during the assessment process it is to be considered as Provisionally Sub-standard until it is confirmed on completion of the assessment to be either adequate or sub-standard.

Formal Interim Measures. Actions complying with clause 1.3 of BD 21.

Other Interim Measures. Measures short of or different from the formal interim measures. These must be in the form of monitoring alone or monitoring with other measures.

Risk. Evaluation of the consequences arising from a hazard together with the probability of its occurrence.

Immediate Risk Structures. Structures which are considered to represent an immediate and unacceptable risk to the public.

Low Risk Provisionally Sub-standard Structures. Provisionally Sub-standard Structures which are considered to be as low risk and therefore not requiring any Interim measures while the assessment is in progress.

Monitoring-appropriate Structures. Structures which are considered to be appropriate for monitoring as an interim measure.

Monitoring. See Appendix C Clause C2.1.

2. ASSESSMENT

2.1 The process of assessment and subsequent action is of crucial importance for ensuring that all highway structures remain in a safe and serviceable state. The assessment rules and criteria involved need to be applied rigorously and in a consistent manner. If assessments are unduly conservative, structures will be unnecessarily strengthened, using up scarce resources and causing traffic disruptions. At the same time, if the rules are lax, or applied unevenly, some structures where the margins of safety are unacceptable may be left without appropriate measures being implemented.

2.2 Whereas all bridges within the assessment programme are to be assessed, for retaining walls, BD 21 recommends that if a retaining wall shows no sign of distress, it may be deemed to be adequate and no assessment is necessary, except when the loading is likely to be increased. During the first year or so following the introduction of the EU 40tonne vehicle, it would be prudent to increase the frequency of inspection to check that the wall remains in sound condition. Thereafter, inspections could return the normal two yearly interval.

2.3 The management of the assessment process and related measures is illustrated in the flow chart in Appendix A. The proforma at Appendix E may be used subject to the Overseeing Organisation's particular needs, as a means of recording the progress of assessments together with specific instructions at significant stages including approvals of Interim Measures.

2.4 Appendix B contains information on the various levels of assessment.

2.5 Each additional level of assessment may involve considerable time and cost. The TAA should consider these implications and approve the progress of the assessment through the various levels. All such deliberations and the conclusions should be carefully recorded.

3. IMMEDIATE RISK STRUCTURES

3.1 The assessing engineer is required to inform the TAA quickly if, during the course of or following the conclusion of the assessment of a structure, an immediate and unacceptable risk to public safety is identified. Once confirmed and agreed with the TAA, appropriate Formal Interim Measures should be implemented as a matter of urgency. Such structures shall be referred to as Immediate Risk Structures.

3.2. In assessing immediate risk to public safety, relevant factors such as the nature of the structural weakness, any corresponding signs of distress, the recent load history of the structure and the level of assessment completed should be taken into account.

3.3 Appropriate measures may consist of one or more of the Formal Interim Measures i.e vehicle weight restriction, lane restriction, propping or closure. A temporary emergency closure may be necessary where there is likely to be a delay in implementing the Formal Interim Measures and the risk of keeping the structure open in the interim period is considered to be unacceptable.

4. INTERIM MEASURES DURING ASSESSMENT

Provisionally Sub-standard Structures

4.1 If at any stage during an assessment, a structure is found to be inadequate and it is considered appropriate that the assessment should continue to another level, the structure shall be considered to be a Provisionally Sub-standard structure. Except for those structures which fall into the low-risk category described below, Formal Interim Measures or Other Interim Measures as appropriate, should normally be applied, particularly if the further assessment work is likely to take any significant length of time.

4.2 Reference should be made to Section 5 below for advice on whether the use of other Interim Measures rather than Formal Interim Measures is appropriate.

Low Risk Provisionally Sub-standard Structures

4.3 Certain Provisionally Sub-standard structures may be considered to be of low risk while assessment is progressing such that it is not necessary to impose any interim measures.

4.4 Low risk bridges may be considered to be those likely to possess considerable reserves of strength, where the consequences of failure are very low, or where the calculated live load capacity factor C is relatively high - for example 0.7 or above.

4.5 Non-carriageway parts of Provisionally Sub-standard decks where risk of imposition of critical wheel/axle loading is seen to be unlikely, may also be considered to be of low risk. In some cases the erection of a partially effective barrier protecting the non-carriageway part may be a necessary measure before the bridge could be considered as low risk.

5. INTERIM MEASURES ON COMPLETION OF ASSESSMENT

5.1 Prior to strengthening or replacement, all Sub-standard structures should be considered as representing a risk to the public until appropriate interim measures as those recommended below have been applied. The purpose of these interim measures is to reduce the risks to levels which are acceptable until strengthening or replacement of the structure is carried out.

5.2 Where an existing weight restriction has been in place on a minor road for some time, and where periodic reviews confirm that the restriction is effective and of benefit, the Overseeing Organisation may consider continuation of the measure as a long term arrangement.

Sub-standard Structures

5.3 Formal Interim Measures should be implemented on all Sub-standard structures as soon as practicable, until permanent remedial works can be implemented.

5.4. In certain cases where imposition of Formal Interim Measures is likely to cause excessive disruption to traffic or incur disproportionate costs, and the structures are identified as Monitoring - appropriate Structures (or non-carriageway parts of bridge decks), Other Interim Measures may be proposed as Departures from Standards to be agreed by the TAA.

5.5 Where an appreciable delay is likely between the completion of assessment and the implementation of the selected Formal Interim Measure, consideration should be given to the management of the risk in the intervening period, for example by applying an Other Interim Measure on a short-term basis.

Monitoring-appropriate Structures

5.6 Sub-standard structures that satisfy **all** the criteria given in (1), (2) and (3) below, and additionally small span bridges as described in (4), may be considered to be Monitoring-appropriate structures subject to TAA approval.

(1) Structures where no sign of significant distress is observed and the form of the structure is such that hidden distress or weakness is unlikely to be present, 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, e.g cracking or local failure at a connection, to more extensive failure before reaching the point where total collapse is precipitated. (In contrast structures whose mode of failure and collapse under traffic load will be sudden and brittle). Furthermore, it must be possible to predict the mode(s) of failure under traffic load with reasonable certainty.

(3) Structures and situations for which monitoring will be meaningful and effective.

(4) Bridges of small span generally less than 5 metres which are in sound condition and where the consequences of failure are low.

5.7 Other Interim Measures may be applied to Monitoring - appropriate structures as a Departure from Standard. Each departure, including the level of monitoring to be applied, should be agreed with the TAA. Appendix C contains information on where monitoring may be justifiable and effective and the three recommended classes of monitoring together with advice on the application of monitoring. Appendix D contains more detailed advice on the types of bridges for which monitoring may be considered appropriate.

5.8 Monitoring by itself does not prevent damage from occurring. The longer monitoring is continued, the greater is the probability of damage, particularly for bridges on heavily trafficked routes. For structures carrying or retaining motorways and trunk roads, Other Interim Measures should therefore be replaced by Formal Interim Measures (or the structure strengthened or replaced) within 2 years from the completion of the assessment. For other structures the Overseeing Organisation may decide to continue a monitoring regime, subject to a 2-yearly review indicating that continuation is acceptable. The review should consider such issues as the monitoring data, traffic levels, effectiveness of the monitoring being carried out, traffic disruption and cost of implementing Formal Interim Measures and the potential disruption and cost if the structure is damaged while being monitored.

Non-Carriageway Parts of Bridge Decks

5.9 BD 21 (cl 1.3) interim measures are not primarily aimed at non-carriageway parts of bridge decks such as verges and their supporting structural elements.

5.10 Appendix J in that Standard does allow the installation of a 'partially' effective barrier such as a safety fence subject to defined vehicle loading checks, which may be considered as a long term solution. This applies to both deck cantilevers as well as non-carriageway parts of beam and slab decks.

5.11 Other forms of barrier which act as a partially effective barrier and which reduce the level of risk to one acceptable to the TAA may be deemed to be an appropriate interim measure.

6. PRIORITISATION FOR STRENGTHENING

6.1 It is possible that the completion of all strengthening and replacement projects at any point of time will take a number of years. The work will therefore need to be prioritised, whilst ensuring the safety of the structures by maintaining appropriate interim measures.

6.2 Prioritisation of strengthening work should take account of the following factors:

(i) the relative risks of the structures to which interim measures have been applied, taking account of the effectiveness of the interim measures, (which may include monitoring only), reserves of strength, different types of bridges etc;

(ii) the traffic delay costs which are caused by the implementation of interim measures and which will be eliminated when the strengthening is complete;

(iii) other social, environmental and economic consequences caused by interim measures to business and community in addition to those related to the traffic delay costs and which will be eliminated when the strengthening is complete;

(iv) the negotiability of alternative routes (including winter conditions and other route related considerations);

(v) the cost-effectiveness of the strengthening, taking account of the ratio of costs and benefits;

(vi) other benefits which will result from the work such as improvements to sight lines and parapets.

7. BIBLIOGRAPHY

Moss, R M and S L Matthews, 1995. In-service structural monitoring, a state-of-the-art review. The Structural Engineer, Vol 73, No.2/17 January 1995.

BS 1881: Part 201: Guide to the use of non-destructive methods of testing hardened concrete.

BS 1881: Part 206: Recommendations for the determination of strain in concrete. Concrete Society “Non-structural Cracking of Concrete - 1992”.

Design Manual for Roads and Bridges

Volume 1: Section 1: Approval Procedures

BD 2 Technical Approval of Highway Structures on Trunk Roads (DMRB 1.1)

Volume 3: Section 1: Inspection

BD 63 Inspection of Highway Structures (DMRB 3.1.4)

BA 63 Inspection of Highway Structures (DMRB 3.1.5)

Volume 3: Section 3: Repair

BA 35 Inspection and Repair of Concrete Highway Structures (DMRB 3.3)

BA 43 Strengthening, Repair and monitoring of Post-Tensioned concrete bridge decks. (DMRB 3.3.2)

Volume 3: Section 4: Assessment

BA 16 The Assessment of Highway Bridges and Structures (DMRB 3.4.4)

BD 21 The Assessment of Highway Structures (DMRB 3.4.3)

BD 34 Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 1 - Older Short Span Bridges and Retaining Structures (DMRB 3.4)

BD 46 Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 2 - Modern Short Span Bridges (DMRB 3.4.1)

BD 50 Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 3 - Long Span Bridges (DMRB 3.4.2)

BA 44 The Assessment of Concrete Highway Bridges and Structures (DMRB 3.4.15)

BD 44 The Assessment of Concrete Highway Bridges and Structures (DMRB 3.4.14)

BA 54 Load Testing for Bridge Assessment. (DMRB 3.4.8)

BD 56 The Assessment of Steel Highway Bridges and Structures (DMRB 3.4.8)

BD 61 The Assessment of Composite Highway Bridges and Structures (DMRB 3.4.16)

Appraisal of existing structures, 1996. Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1X 8BH.

Moore J F A (Ed) 1992. Monitoring building structures. Blackie.

Monitoring of large structures and assessment of their safety. Colloquium, Bergamo 1987, IABSE report Vol 56.

8. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

Divisional Director Civil Engineering
Quality Services
The Highways Agency
St Christopher House
Southwark Street
London SE1 0TE

A J PICKETT
Divisional Director Civil Engineering

The Deputy Chief Engineer
The Scottish Office Development Department
National Roads Directorate
Victoria Quay
Edinburgh EH6 6QQ

N B MACKENZIE
Deputy Chief Engineer

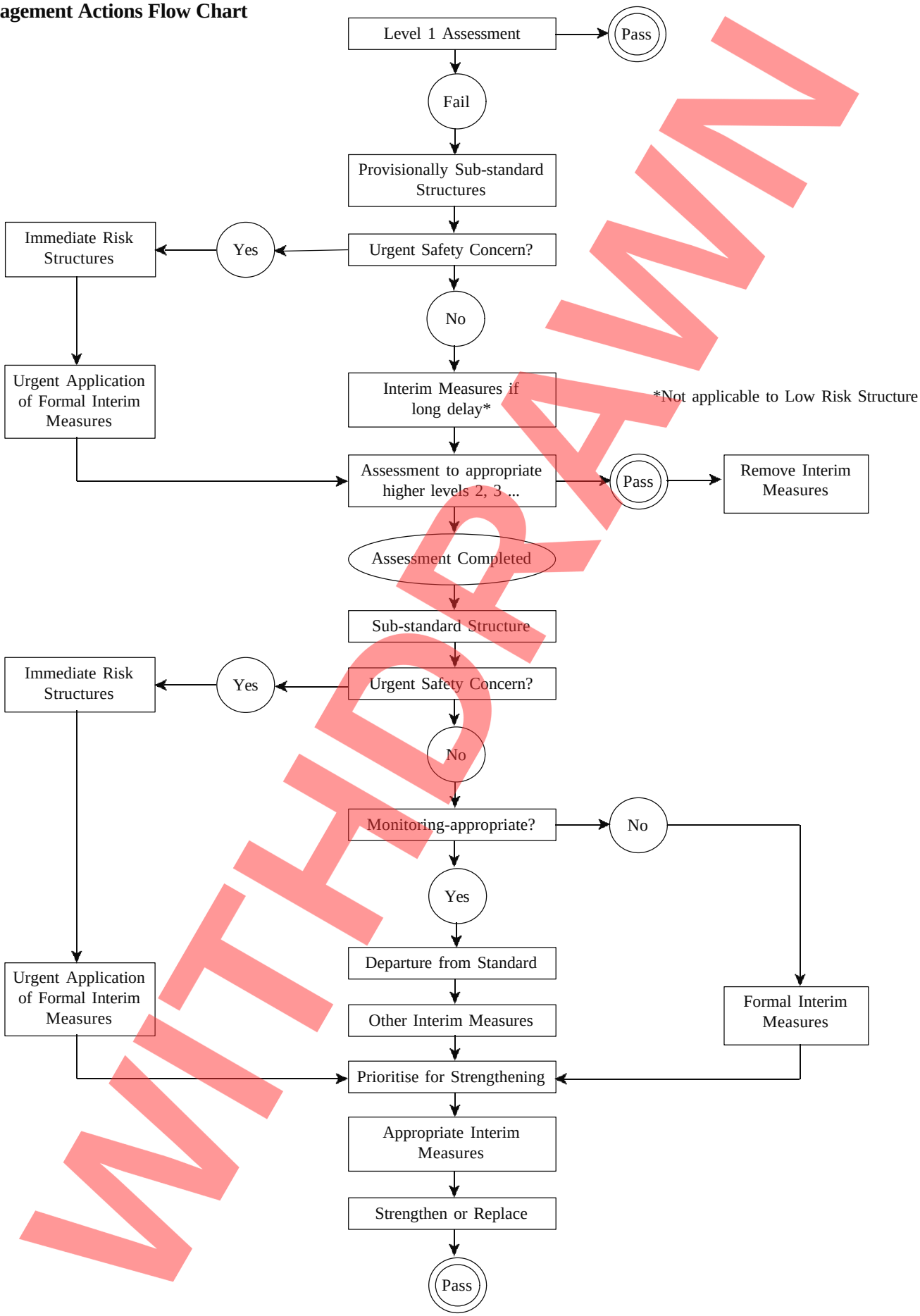
The Director of Highways
Welsh Office
Y Swyddfa Gymreig
Crown Buildings
Cathays Park
Cardiff CF1 3NQ

K THOMAS
Director of Highways

Assistant Technical Director
Department of the Environment for
Northern Ireland
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

D O'HAGAN
Assistant Technical Director

Management Actions Flow Chart



PRINCIPLES AND LEVELS OF ASSESSMENT

B1. GENERAL

B1.1 The purpose of assessment of structures is to check their adequacy for specific loading levels and to identify those bridges which have an unacceptable risk of failure, either in part or complete collapse, under extreme circumstances of loading and material condition.

B1.2 Structural failure can result in personal injury accidents as well as loss of asset value and amenity.

B1.3 Structural failure is not acceptable to the public; hence the order of the probability of failure inherent in the assessment criteria is very small. When a structure is assessed to be sub-standard, it does not mean therefore that it will necessarily fail or collapse. However, if such structures were left in large numbers without remedial action, there may be an unacceptable risk that a collapse in service would occur. The assessments are based on probabilities and therefore it is impossible to know beforehand which bridges would actually fail in practice.

B1.4 A sub-standard structure which has a low assessed capacity would not necessarily fail before another structure which has a higher assessed capacity. Actual failure depends upon a number of factors, including the actual load levels that occur.

B1.5 Many of the factors that bring about structural collapse cannot be taken into account in calculation, e.g. undiscoverable condition, freak events. However, calculation-based assessments are the only practical means available at present for gaining assurance about the adequacy of the whole stock of highway structures.

B1.6 The absence of any apparent signs of distress in a Sub-standard structure does not mean that it is structurally adequate. When the failure mode is likely to be brittle there may be no early warning signs. Furthermore, end restraint or composite action which cannot be relied upon at all times in certain older structures, may temporarily prevent such a structure from showing distress.

B1.7 Assessment of an existing structure may be carried out, if it fails the initial assessment, in stages of increasing complexity, with the object of determining its adequacy with minimum effort. Early stages may contain conservative means of determining load effects. Provided that a structure is shown to be adequate at these stages, then no further analysis would be required. However if a structure is found to be inadequate at an early stage then assessment work should continue, and later stages should seek to remove any conservatism in the assessment calculations in order to minimise the number of sub-standard structures arising from the assessment programme. In some cases, the end result will quickly become self-evident and the process can be terminated at an early stage.

B1.8 The methods of assessment have been the subject of considerable Research and Development effort in recent years; as a result it is now possible to carry out assessments in five distinct levels. These levels of assessment, numbered 1 to 5 with Level 1 being the simplest and Level 5 the most sophisticated, are set out below. Means for carrying out assessments at Levels 1, 2 and 3, are contained within existing assessment Standards and Advice Notes whereas those for Levels 4 and 5 go beyond the advice available in existing DMRB Standards and Advice Notes. Any assessment carried out at these levels requires detailed approval of the TAA concerned.

B1.9 Intermediate levels of assessments may be omitted in agreements with the TAA.

B2. LEVEL 1 ASSESSMENT

B2.1 This is the simplest level of assessment, giving a conservative estimate of load capacity. At this stage, only simple analysis methods are necessary, and full partial safety factors from the assessment standards are used.

B2.2 To facilitate such an assessment, the assessment Standard BD 21 and the accompanying Advice Note BA 16 have been developed. These documents themselves represent a considerable relaxation compared to design standards, which would be the only alternative in their absence. It should be recognised that the use of design standards for assessment would result in structures failing assessment unnecessarily.

B2.3 In addition to BD 21, assessment versions of the design standards for concrete, steel and composite bridges, i.e BD 44, BD 56 and BD 61 respectively, have also been developed for the purpose of providing more realistic assessments for these bridge types. The implementation documents for the 3 Assessment Stages (BD 34, BD 46 and BD 50) are also relevant.

B3. LEVEL 2 ASSESSMENT

B3.1 This next level of assessment involves the use of more refined analysis and better structural idealisation as indicated by the existing Standards and Advice Notes.

B3.2 More refined analysis may include grillage analyses or possibly finite element analyses whenever it is considered that these may justify higher capacities. Non-linear and plastic methods of analysis (e.g. yield line or orthotropic grillages) may also be used. (Refer to Section 4.4.3 BD 44./95).

B3.3 This level also includes the determination of characteristic strengths for materials based on existing available data. This may be in the form of existing mill test certificates or recent tests on another similar structure (e.g. Section H.4.1 Appendix H Annex A BD 56/96). If any new tests are to be carried out on the structure being assessed then this should be considered as a Level 3 assessment.

B4. LEVEL 3 ASSESSMENT

B4.1 Level 1 and Level 2 assessments make use of Assessment Live loadings from BD 21 for short span bridges and from BD 50 for long span bridges but without the use of Bridge Specific Assessment Live Loading (BSALL). Level 3 assessment includes the option to use BSALL.

B4.2 For short span bridges (loaded length less than 50m), it is generally not considered cost effective to develop Bridge Specific Assessment Live Loadings. The refinements included in the 1997 version of BD 21 already take account of varying traffic flows and surface irregularities.

B4.3 For long span bridges, where the 40 Tonne assessment fails by a small margin and where the bridge is located on a lightly trafficked road, then use of BSALL may be beneficial. Reference should be made to BD 50.

B4.4 Level 3 assessment may make use of both material testing to determine characteristic strength or yield stress, and also Worst Credible Strength or Worst Credible Yield Stress. Reference should be made to BD 44 and BA 44 for the Worst Credible Strength and to Appendix H of BD 56 for Worst Credible Yield Stress procedures.

B5. LEVEL 4 ASSESSMENT

B5.1 Level 1 to 3 assessments are based on code implicit levels of safety, incorporated in the nominal values of loads and resistance parameters and the corresponding partial safety factors. The corresponding reliability is related by implication to past satisfactory performance of the bridge stock through calibrations where these have been carried out.

B5.2 Any calibration involves an element of averaging which makes the results acceptable for the bulk of the structures of the type concerned. Nevertheless, the resulting rules may be over conservative for a particular structure which may be significantly different in some way from the norm used in the calibration. Level 4 assessments can take account of any additional safety characteristic to that structure and amend the assessment criteria accordingly.

B5.3 Any changes to the criteria used in this level may be determined through rigorous reliability analysis, or by judgemental changes to the partial safety factors.

B5.4 In the deliberations involving Level 3 assessments, care should be taken not to double count bridge specific benefits which have already been taken into account. For instance, bridge specific loading is considered in Level 4. Similarly if system analysis based methods such as the yield line method have been used in Level 2 or 3, system effects should not be utilised in Level 4.

B5.5 Level 4 assessment may be beneficial in the following circumstances:

(1) The bridge assessment criteria have been primarily devised for longitudinal effects on main deck members. All other elements such as cantilever slabs, cross beams, pierheads etc may be examined in Level 4 for determining element specific target reliability.

(2) The whole life reliability of a structure, in the absence of any significant deterioration, increases from the day it is constructed to the end of its functional life. This effect has not been taken into account in the present criteria.

(3) A bridge over a very small watercourse is inherently safer than the average bridge, because of its much lower consequence of failure. Such considerations may be used in a Level 4 assessment.

B5.6 The background knowledge and engineering judgement required for this level of assessment is of a high order and hence, the TAA needs to be closely involved.

B6. LEVEL 5 ASSESSMENT

B6.1 Level 5 assessment involves reliability analysis of particular structures or types of structure. Such analyses require probability data for all the variables defined in the loading and resistance equations. The techniques for determining the probability of failure from such data are now available and can be undertaken relatively easily in modest time frames.

B6.2 Level 5 assessment provides greater flexibility but it should be noted that the results are very sensitive to the statistical parameters and the methods of structural analysis used. At present therefore Level 5 assessment should not be used in conjunction with a prescribed target reliability, as there is no guarantee of achieving consistency in different assessments. However Level 5 may be used if the target reliability is determined specifically by the same Assessing Organisation for a class of identical structures or structural elements, e.g. pier cross-heads, taking the reliability of the structures as designed in respect of the assessment load, as the target reliability.

B6.3 Level 5 assessments require specialist knowledge and expertise and are only likely to be worthwhile and possible in exceptional cases. If Level 5 assessments are proposed, the TAA should be consulted in respect of the methods and criteria to be used.

B7. TECHNICAL APPROVAL AND CERTIFICATES

B7.1 Requirements for Technical Approval relating to assessment of structures are given in BD 2. The scope and complexities of assessment develop as the assessment progresses; with increasing input of subjective judgement. It is therefore essential that there is dialogue between the assessing engineer and the TAA, particularly when assessment Levels 4 and 5 are being used.

B7.2 Normally amendments to an Approval in Principal (AIP) will be required for each level of assessment proposed. This may be conveniently formalised by an addendum to the original AIP.

B7.3 As any assessment progresses through the successive levels of sophistication, the TAA should carefully consider the value in continuing the technical investigations, e.g they may become excessively costly and time consuming, and in some cases ultimately prove to be futile or of marginal use. A fine balance needs to be drawn in this respect, keeping in mind that an unjustified assessment failure can mean a greater wastage of scarce resources.

B7.4 Adequate records must be kept throughout the assessment process with details of the decisions taken at each stage.

MONITORING OF SUB-STANDARD STRUCTURES

C1. GENERAL

C1.1 This Appendix gives advice on the application of monitoring and describes different classes of monitoring for structures found to be Monitoring-appropriate in the assessment process.

C1.2 The class of monitoring should be selected to suit the circumstances of the particular structure and its assessed inadequacy in order to provide the level of additional assurance required. It is to be emphasised that at the lowest level, monitoring may be limited to visual inspection and recording information.

C1.3 Once in operation, any unexpected or potentially critical change in the condition of the structure or its loading revealed by the monitoring should be examined urgently to determine the next course of action.

C1.4 **Ensuring the safety of a sub-standard structure through monitoring, with or without other measures, is a complex process and requires in depth knowledge of the techniques and the potential problems. This is not to be undertaken in a casual manner and appropriate professional engineering expertise and advice should be sought and used throughout.**

C1.5 Where weight restrictions on a bridge have been implemented, consideration should be given to the likely extent of compliance, level of policing and need for systematic monitoring.

C1.6 All highway structures are, as a minimum, subjected to basic visual inspections (General Inspections) and more detailed inspections (Principal Inspections) generally at intervals described in BD 63. Such inspections are appropriate and necessary where the structure meets the requirements of BD 21.

C1.7 Monitoring in accordance with this Advice Note may be used alone or with other measures for Monitoring-appropriate structures assessed to be sub-standard. The purpose of this monitoring is to contribute to the assurance of the safety of a structure enabling it to remain in service.

C1.8 The extent of monitoring will depend on the type of structure, its condition, current circumstances, other Interim Measures proposed and the structural inadequacies in assessed capacity. The monitoring should be continued until the bridge has been strengthened or replaced, or Formal Interim Measures have been implemented. In some cases it may be appropriate to monitor in conjunction with Formal Interim Measures.

C1.9 Types of inadequacy that may be inherent in a Sub-Standard structure are given below:

(1) The assessment calculations indicate that the load carrying capacity is inadequate for the following reasons:

a) the original design loading being lower than that now required; and/or

b) other principles and criteria used in the original design being less onerous than those now adopted for assessment.

(2) There is an error in design or construction that has resulted in a specific potential weakness, without which the carrying capacity would be adequate.

(3) There has been deterioration or damage since construction sufficient to reduce the assessed capacity, without which the structure would have been adequate. Deterioration may be continuing, thereby reducing the capacity still further.

(4) Ad hoc/rule of thumb construction, not formally designed for any traffic loading.

C1.10 Two or more of these types of inadequacy may be present in combination. For structures falling within the scope of C1.9 (2) or (3), the primary objective will normally be to monitor the deficient part of the structure or the development of deterioration. For structures falling within the scope of C1.9 (1), the assessment calculations provide the basis for identifying the critical areas for monitoring.

C1.11 Any of the above inadequacies may be present in a structure without visible signs of structural distress. Cracking with associated corrosion may be present where it is hidden from visual inspection, e.g in the webs of contiguously placed beams or under the surfacing in hogging regions. Such possibilities should be taken into account when planning a monitoring scheme.

C1.12 It is important to consider the reasons for the absence of predicted live load distress for all sub-standard structures particularly for those within the scope of C1.9 (1). The possibilities of deterioration in performance should also be considered and how this can be identified by monitoring. In some circumstances evidence of deterioration may be found in an area other than the one assessed as inadequate: eg an inadequacy in mid-span flexure, relieved in practice by moment restraint at supports, may first be indicated by the onset of movement at the supports rather than distress at mid-span.

C2. DEFINITIONS

C2.1 For the purposes of this Advice Note monitoring is defined as:

The *periodic* or *continuous observation* and *recording* of *information* pertaining to structural behaviour, the primary purpose being to detect *deterioration* should it occur.

where:

Periodic refers to observations carried out at discrete times with intervals between them measured, in general, in weeks or months;

Continuous refers to an observation that continues without break in which a continuous record is made or maxima and minima are recorded, or to one that takes place at sufficiently small intervals to be considered continuous;

Observations are most commonly obtained by visual inspection but they may also include measurement made using transducers, strain gauges, probes or other instruments;

Recording refers to writing down information from visual observations, measurements or test data, photography, or the automatic storage of information on charts, printers, magnetic media or other similar;

Information may be qualitative such as the presence of staining or other defects or quantitative such as the dimensions of cracks, profile of span, strain or deflection, or readings obtained from non-destructive testing methods.

Deterioration refers to a decline in condition, integrity or performance arising from any cause -including an aggressive environment, loading and impact - resulting in, for example, corrosion-induced spalling, load-induced cracking or changes evidenced by strain/displacement measurement.

C3. ESSENTIAL REQUIREMENTS FOR MONITORING

C3.1 The essential requirements for applying monitoring as an interim measure are:

(1) The parameter(s) to be monitored should be clearly defined, directly related to the predicted mode(s) of failure and capable of being observed to the required degree of accuracy and frequency;

(2) It should be clear what constitutes acceptable observations of the parameter(s) and what constitutes alarm levels, indicating that the structure is approaching a condition in which continued use is unacceptable;

(3) Monitoring should be able to detect warnings indicating distress of critical elements associated with the predicted mode(s) failure of the structure caused by loading;

(4) The mode of failure of the structure as a whole should be such that the monitoring system will respond sufficiently quickly to ensure traffic management measures can be implemented BEFORE progressive loss of structural integrity reaches the point at which catastrophic collapse would occur;

(5) The results and records of monitoring should be formally documented and easily traceable within filing/data record systems.

C3.2 An essential starting point in considering whether to implement a monitoring regime for a structure is the criteria for Monitoring-appropriate bridges given in paragraph 5.5 of this Advice Note. Other key issues to be considered are its specific purpose, what events, distress or deterioration may possibly occur, the ability to observe them and the consequences should they not be detected.

C3.3 The presence of structural distress is an important criteria requiring careful consideration. Where distress in a structure appears to be recent, significant or to have resulted from live load effects, monitoring in service may not be appropriate without other measures being implemented. Other types of distress, particularly distress of a minor nature, is unlikely to invalidate monitoring provided its significance and effects can be accounted for.

C3.4 When the above considerations lead to doubt about the effectiveness of a monitoring regime, monitoring should not normally be relied upon alone without the implementation of other interim measures. Where another interim measure is in place, a monitoring regime may be devised to provide assurance that the measure is functioning as required. Thus, for example, if temporary propping is installed, monitoring inspections may be used to check continued integrity of the temporary props and to check for signs of movement, distress or degradation.

C4. CLASSES OF MONITORING

C4.1 A principal objective of all classes of monitoring is the detection of deterioration in structural behaviour or condition, should it occur. The monitoring regime for a structure should be defined in detail in each specific case. The three monitoring classes described below may serve as a starting point for more detailed specification. Class 1 is the lowest class of monitoring and Class 3 the highest: Class 2 includes all the Class 1 provisions and Class 3 all the Class 1 and 2 provisions.

Class 1 - Basic Monitoring

C4.2 Class 1 monitoring consists of visual observations and recording, including photography. Measurements are not normally undertaken, but the condition of the critical parts of the structure are noted and compared with previous records.

Inspection at touching distance is normally required. Simple operations, such as hammer tapping to check for delamination or loose members, may be included. Recording of traffic flows and composition may be required. Observations are normally carried out at intervals of weeks or a few months and should normally be more frequent than for a structure which meets the requirements of BD 21.

If deterioration occurs, the cause should be detectable wherever possible from the visual inspection: for example, the condition may have deteriorated as a result of corrosion or load induced cracking. When deterioration occurs the level of monitoring should be reviewed.

Class 2 - Detailed Monitoring

C4.3 Class 2 monitoring includes the provisions of Class 1, supplemented as appropriate by one or more of the following:

(i) Recording of quantitative information which may include: the extent and nature of deterioration, eg the locations and dimensions of areas affected, the length, width, depths and spacing of cracks; a level survey repeated periodically; non-destructive testing.

(ii) Measurement of parameters such as displacement or strain at typical[1] or critical positions. This may include measurements to detect changes in permanent or transient effects; records may be continuous, instantaneous or maximum/minimum. At the outset, in-situ stress determination may be required. These techniques are likely to be applicable when it is required to confirm that there is no change in the structural action/condition, or response to traffic loading, where visual inspection is not sufficient.

(iii) Measurement of parameters such as strain or displacement at particular defects, or in areas associated with damage or deterioration, in a bridge otherwise not sub-standard.

(iv) Extended traffic loading survey as appropriate.

C4.4 The frequency of observations for Class 2 monitoring can differ, depending on the bridge, from periodic visits at intervals of several months, to more frequent visits or to continuous monitoring. Determination of the frequency should take into consideration the most likely modes of failure, its progression and consequences and the ability of the monitoring system to detect warning of progression. If deterioration occurs, the cause should be identified.

Class 3 - Extensive Monitoring

C4.5 Class 3 monitoring is the highest level of monitoring. It may require frequent or continuous monitoring in one or more of the Class 2 categories where the onset of change is predicted to progress significantly towards failure in a short time. Measurements carried out in typical or critical positions, as appropriate to Class 2 monitoring, may be insufficient and a more extensive coverage of potentially critical points is likely to be required. It may be necessary to apply other interim measures in addition, such as temporary propping or traffic restrictions.

C4.6 Class 3 monitoring will often require continuous monitoring using data loggers and, where appropriate, remote monitoring techniques. Automatic alarm systems may be installed, to give warning when a parameter goes outside a pre-determined limit.

C5. SELECTION OF APPROPRIATE MONITORING CLASS

C5.1 It is likely that a visual inspection regime (Class 1) will be sufficient in many cases to give adequate assurance of safety. Sound structures (ie structures having a sound structural form with no significant defects but which assessment indicates have sub-standard load-carrying capacity) with no signs of distress and with an inadequacy as described in paragraph C3.4(1) are likely subjects for this type of monitoring. The predicted mode of failure of the structure and its speed of progression over time are important considerations. Where the mode of failure is such that the structure will gradually - over a period of (at least) several weeks - show visual signs of increasing distress as traffic continues to use the bridge, then a visual inspection regime may be appropriate.

[1] *The use of the word typical is intended to refer to a situation in which, for instance, one typical beam might be* monitored from a multi-beam span, or one typical span from a multi-span deck. This would act as a check on progression to distress. If a progression was observed the situation should to be reviewed, and, if it was decided to allow the structure *to continue in service, monitoring of more locations might be required.*

[2] *This is an important point. Used in the manner suggested, it is not necessary to estimate the behaviour under* Ultimate Limit State factored loads, and therefore uncertainties in this process are not an impediment.

C5.2 When an evaluation of the structure indicates that additional assurance is required, then measurement using a small number of instruments placed at typical positions may be justified in accordance with a Class 2 monitoring regime. This might be appropriate when, for example, there would be an advantage in detecting any increase in maximum strain under live load or in the dead load condition. A Class 2 regime might also be appropriate when it is desired to increase the intervals between visual inspections. The use of instrumentation may also be needed where access for regular visual inspection of critical elements is not practical.

C5.3 The higher classes of monitoring should be considered when the predicted mode of failure and its speed of progression towards bridge collapse might be quite rapid once visual signs are present. When visual signs are likely to occur only when progression towards collapse is well advanced, monitoring should allow detection as soon as possible. Depending on the likely timescales involved, a high frequency of visual inspection, or intermittent or continuous monitoring (Class 2 or Class 3), using instrumentation in addition to visual inspection should be considered - for example, where the structure has a defect or advanced degradation in a critical element, or the critical element is sound but under-strength, and failure under high traffic load would lead to sudden collapse. In these circumstances the adoption of monitoring alone should be considered with particular caution, the need being to ensure the monitoring system will provide adequate warning of collapse.

C5.4 Class 3 monitoring will normally be required on a structure where it is necessary to allow a high level of loading to continue, although the inadequacies of the structure are substantial and its strengthening or replacement is given a high priority. It may have a combination of defects. A decision to increase the level of monitoring from Class 2 to Class 3 may be influenced by the perceived consequences of failure.

C6. MONITORING SPECIFICATION

C6.1 The monitoring regime for each Sub-standard structure should be specified in a clear, unambiguous procedure document. Except where the monitoring is intended merely to check that other forms of interim measure are continuing to function satisfactorily, the procedure document should include the following:

(1) The basis of the assessment inadequacy, stated clearly but concisely. Generic reasons such as “flexure” or “shear” are not sufficient: the location, nature, degree and underlying reasons should be stated, and the factor K given (see BD 21). When there are several inadequacies, each should be described and an overview given.

(2) An appraisal of the reasons for the observed satisfactory service performance: for example, low load levels, conservative structural model, conservative resistance model, resistance enhancement;

(3) The anticipated mode(s) of failure together with an indication of the likelihood and consequences of such failure;

(4) A description of the parameters to be monitored and their relationships to the predicted mode(s) of failure and progression to that state, together with the required accuracy of observation and frequency of monitoring;

(5) A description of the ranges of observations which are acceptable and the values, or other features, which constitute alarm or warning levels requiring action;

(6) A clear set of procedures to be implemented if alarm or warning levels are reached. These should include contact names and telephone numbers and should be clear as to who has the responsibility for each decision;

(7) Recording and reporting requirements; and

(8) Provision for review of the monitoring regime or procedures following observed behaviour of the structure.

C6.2 The proposed monitoring regime should normally be specified following a special inspection unless recent inspection records are adequate for the purpose.

Volume 3 home page

NOTES ON IDENTIFYING MONITORING - APPROPRIATE BRIDGES

D1. MONITORING - APPROPRIATE BRIDGES

D1.1 Types of Sub-standard bridge which are likely to be Monitoring - appropriate include:

- Reinforced concrete slab bridges or composite steel and concrete slab bridges with theoretical longitudinal or transverse flexural inadequacy, especially where adequate continuity exists over the supports.

- Bridges in which the structural inadequacy is in an element or connection whose failure would not precipitate sudden collapse and whose failure can be observed by monitoring. The inadequacies may be in flexure, shear or anchorage. The crucial feature is that the bridge will retain a substantial proportion of its load carrying capacity following element/connection failure until the failure is detected and safeguarding measures are implemented.

- Bridges of small span generally less than 5 metres which are in a sound condition and where the consequences of failure in terms of death and injury or traffic delay costs etc. are low, providing they can be adequately monitored.

D1.2 Types of Sub-standard bridges that are not normally Monitoring-appropriate include bridges that are sub-standard by virtue of tension, shear or anchorage inadequacies where failure in tension, shear or anchorage would precipitate collapse of the bridge.

D2. FACTORS INFLUENCING CHOICE OF MONITORING CLASS

D2.1 The following discussion which is not exhaustive, indicates some of the important factors which may need to be considered in defining the monitoring regime for a particular Sub-standard bridge.

Sub-standard bridges with flexural inadequacies

D2.2 Examples of flexural inadequacy where monitoring requirements may usually be met are:

- Bridges where the theoretical structural inadequacy is in an element or connection, or type of load effect, where its failure can be observed by monitoring if it should fail, and where the failure will not cause sudden collapse of the bridge span.

- Bridges where there is a theoretical flexural inadequacy which may lead, under repeated or increasingly heavy load, to progressively increasing permanent or transient deflection or strain.

An inadequacy in transverse flexure in a reinforced concrete slab bridge places the bridge in the first of these two categories: i.e longitudinal cracking might occur initially, but collapse would not be expected to follow until longitudinal failure took place with accompanying transverse cracking. For an inadequacy in longitudinal flexure at mid span, the bridge might fall into the second category.

D2.3 It should not be assumed automatically that any flexural inadequacy is suitable for Class 1 monitoring: moreover a combination of circumstances might prevent such a bridge being classified as Monitoring-appropriate. Difficulties may arise where the tension fibre cannot be observed, such as the top surface of a built-in slab, portal or box culvert. This would lead to a higher level of monitoring, say Class 2: strain gauges might be attached in typical positions to detect changes in sagging before cracking occurs or instrumentation might be placed on the concealed surface. However, provided there is sufficient ductility, and cracking would be expected to occur on the visible face before failure, a Class 1 monitoring regime would be sufficient.

D2.4 There may be the potential for a more sudden type of flexural failure with less displacement and cracking when the inadequacy lies not in the percentage of reinforcing steel, but in laps or anchorage. The margin between the cracking moment and the ultimate moment should also be considered: the greater the potential warning. In rare cases the ultimate moment could be less than the cracking moment.

D2.5 Similar issues in steel or composite bridges require a distinction to be made between tension or compression failure in flexure, whether or not the section is compact or if buckling is likely, or whether the resistance would change suddenly as a result of the failure at an interface. Imperfections are likely to have an effect on the appraisal, as is the practicality of measuring out-of-plane displacements.

D2.6 Wide bridges - some bridge types are less likely to fail catastrophically in flexure under traffic loading where they are wide and carry several lanes. In the case of a single lane bridge, one vehicle could cause a loading event of significantly greater magnitude than the bridge had previously experienced. When there are more lanes the maximum loading is more likely to build up gradually over time if local traffic conditions change, and failure has to occur over the full width if collapse is to take place.

D2.7 Narrow bridges - statically determinate bridges with a global flexural inadequacy under single vehicle or axle loading will not normally satisfy the requirement for gradual progression of distress which can be monitored by visual inspection alone at intervals of several weeks. For them to be Monitoring-appropriate more frequent visual inspection or instrumentation to detect progression of distress would be needed.

D2.8 Where spans are continuous and thus redundancies are present, a collapse mechanism may begin to form long before collapse becomes imminent. Inadequacies in torsion are more significant when the torsional resistance is required for equilibrium purposes.

Sub-standard bridges with shear inadequacies

D2.9 Bridges with shear inadequacies are not generally suitable for monitoring. Monitoring may however be considered where the bridge is wide. For concrete bridges it should be considered only where either:

- Visible flexural cracking would precede shear distress and act as an early warning or
- Inclined cracks would occur on surfaces that can be observed.

There must be an adequate margin between first cracking and maximum shear capacity which may be determined by consideration of the degree of theoretical inadequacy, a comparison between the code provision and the test results from which it is derived, and other factors such as redundancy, width of structure, susceptibility to loading by a single vehicle and the dead load/live load ratio.

Narrow bridges with shear inadequacies are not suitable for monitoring when C for shear (see BD 21) is less than 0.5, and not when it is less than 0.6 unless inclined cracks would be visible and sufficient shear reinforcement is present to provide a significant capacity margin above the inclined cracking load. Bridges with sub-standard shear details, such as inadequate anchorage, are not generally suitable for monitoring.

Sub-standard masonry arch bridges

D2.10 Masonry arch bridges are suitable for monitoring only when it is considered that there is a significant margin of strength above the assessed capacity and adequate signs of distress will arise under high vehicle load sufficient to forewarn of vulnerability to collapse.

Factors to be considered include:

- The presence and effect of strengthening features that have not been accounted for in the assessment such as internal walls, robust spandrel/wing walls.
- The type of arch ring and its influence on observable deterioration: e.g dressed stone masonry (defects usually visible?), multi-ring bridge (is hidden ring separation present?), rubble masonry (is deterioration obscured?)

- The arch ring shape and its potential for sudden collapse: e.g circular, with a high or low span-to-rise ratio, elliptical, the effect of haunching.

- The condition of the foundations and the potential for movement to produce sudden failure: e.g has a saddle increased the eccentricity of thrust?

- There may be an additional risk when defects have been subjected to cosmetic repairs which conceal faults, for example the detachment of a spandrel wall or arch ring separation.

Modes of Collapse

D2.11 Potential modes of collapse, in particular, progression from local failure and suddenness, will be strongly influenced by the structural form, especially the extent of redundancy and the presence of alternative load paths. When relying on alternative load paths, there should be no weak links in the redundant path.

D2.12 When attempting to foresee possible modes of failure it should be borne in mind that the C factor (see BD 21) for each inadequacy may not give a definitive indication of the collapse mode, or the load effect that will first show signs of distress. Alternatives should be reviewed to ensure than a sudden mode of failure has not been overlooked.

Recent structural distress

D2.13 For Sub-standard bridges where distress appears to be recent, significant and detrimental to the immediate safety of the bridge, monitoring in service is unlikely to be appropriate by itself. Other types of distress and, in particular, distress of a minor nature, may not invalidate monitoring provided its significance and effects can be accounted for.

When monitoring alone is insufficient

D2.14 When the required criteria and requirement cannot be satisfied, monitoring should not be relied upon alone and another interim measure or measures should be implemented. Where another interim measure is in place, a monitoring regime may be devised to provide assurance that the measure is functioning as required. Thus, for example, if temporary propping is installed, monitoring inspections may be used to check continued integrity of the temporary props and to check for signs of movement, distress and degradation.

INTERIM MEASURES APPRAISAL PROFORMA FOR BRIDGES

1. GENERAL DETAILS **Date:**

1.1 Structure name and assessment reference:
Structure Ref No:
(Form 277 to be attached)

1.2 Location, route and county/area:

1.3 Assessing Organisation:
Assessed by:
Checked by:
Assessment date:

1.4 Estimated cost of permanent strengthening/replacement works:

1.5 Structure type, form, span, skew:

1.6 Obstacle crossed or facility carried:

2. ASSESSMENTS IN PROGRESS

2.1 Stage reached in assessment process (1,2,3,4 or 5):

2.2 Preliminary assessed capacity:

2.3 Description of any further assessment being carried out:

2.4 Departures being considered/sought:

2.5 Any preliminary precaution advised including interim measures (a) to (c) of paragraph 4.1

3. ASSESSMENTS COMPLETED

3.1 Assessed capacity:

3.2 Location, extent, nature of deficiencies:

3.3 Description of anticipated mode of failure from local overstress to global collapse mechanism:

4. INTERIM MEASURE OPTIONS TO BD 21 REQUIREMENTS

4.1 BD 21 compliant options (feasibility):
(to be completed for all 3 options)

(a) Weight/width restrictions plus monitoring:

(b) Propping/temporary bridge plus monitoring:

(c) Closure and diversion of traffic:

4.2 Operational and cost implications of implementation of paragraph 4.1 options:

(a)

(b)

(c)

4.3 Other implications of implementation of paragraph 4.1 options:

(a)

(b)

(c)

5. INTERIM MEASURE OPTIONS NOT IN ACCORDANCE WITH BD21 REQUIREMENTS

5.1 Description of interim measure (any monitoring strategy should make direct reference to paragraph 3.3. Distress is defined as cracking/deflection consistent with paragraph 3.3 predictions).

5.2 Risk justification for implementation of paragraph 5.1 option (This should make reference to the likelihood of collapse and the role of monitoring in providing warning and the traffic implications of loss or damage of the structure).

5.3 Consequences arising from structural collapse or damage at lower than collapse load:

5.4 Operational and cost implications of implementing paragraph 5.1 option:

5.5 Other implications of implementing paragraph 5.1 option:

6. ACCEPTANCE OF PROPOSED ACTION TO BD 21 OR AUTHORISATION OF DEPARTURE FROM STANDARD (IN COMPLIANCE WITH THE OVERSEEING ORGANISATION'S REQUIREMENTS)

6.1 Recommended BD 21 compliant Formal Interim Measure option 4.1(a), 4.1(b), 4.1(c)

..... Assessment team for assessing organisation

..... Director / Partner for assessing organisation

6.2 Acceptance of proposed Formal Interim Measures action

..... TAA

..... Bridge owner (if different from TAA)

..... Highway Authority (if different from TAA)

6.3 Alternative Other Interim Measures (5.1)
(Note that the need to present such options should be discussed with the TAA)

..... Assessment team for assessing organisation

..... Director / Partner for assessing organisation

6.4 Appraisal of alternative Other Interim Measures (acceptance of appraisals presented)

..... TAA

6.5 Instruction to implement 5.1 option

..... Bridge owner or Highway Authority

Note to Section 6.

1. Assessing organisation will sign at 6.1 (and optionally at 6.3)
2. TAA will sign at 6.2 *or* 6.4 and 6.5
3. Appropriate officer of the Highway Authority or the Bridge Owner (not the TAA) will sign at 6.5
4. Private bridges - Further signatories at 6.2 and 6.5 will permit relevant parties to endorse action to be taken

INTERIM MEASURES APPRAISAL PROFORMA FOR RETAINING WALLS

1. GENERAL DETAILS

1.1 Structure name and assessment reference:
Structure Ref No:
(Form 277 to be attached)

1.2 Location, route and county/area:

1.3 Assessing Organisation:
Assessed by:
Checked by:
Assessment date:

1.4 Estimated cost of permanent strengthening/replacement works:

2. DEFORMATION DESCRIPTION:

2.1 Bulging:

2.2 Tilting:

2.3 Sliding:

3. EXTENT OF DEFORMATION:

3.1 Height and width: Maximum retaining height of wall: m
Average retained height of wall: m

3.2 Deviation from line vertical:

4. HISTORY:

4.1 General Inspection or Principle Inspection references to deformation:

5. INTERIM MEASURE OPTION TO BD 21 REQUIREMENTS:

5.1 BD 21 compliant options (feasibility):
To be completed for all 3 options i.e. (a), (b) and (c) below).

(a) lane restrictions plus monitoring:

(b) propping and monitoring:

(c) closure:

5.2 Operational and cost implication of implementation of paragraphs 5.1 options:

(a)

(b)

(c)

5.3 Other implication of implementation of paragraphs 5.1 options:

(a)

(b)

(c)

6. INTERIM MEASURE OPTIONS NOT IN ACCORDANCE WITH BD 21 REQUIREMENTS:

6.1 The Assessor is required to use engineering judgement to describe the options with reference to:

1. the history of deformation (paragraph 4.1);
2. the percentage of total loading effects attributable to live loading;
3. the sensitivity of the wall to variation in magnitude and position of vehicle loading:

6.2 Description of the interim measure:

6.3 Possible consequences of the wall collapsing in service despite paragraph 6.2 interim measure:

6.4 Reasons for monitoring frequency:

6.5 Operational and cost implications of implementation of paragraph 6.2 option:

6.6 Other implications of implementation of paragraph 6.2 option:

7. ACCEPTANCE OF PROPOSED ACTION TO BD 21 OR AUTHORISATION OF DEPARTURE FROM STANDARD (IN COMPLIANCE WITH THE OVERSEEING ORGANISATION'S REQUIREMENTS)

7.1 Recommended BD 21 compliant Formal Interim Measure option 4.1(a), 4.1(b), 4.1(c)

..... Assessment team for assessing organisation

..... Director / Partner for assessing organisation

7.2 Acceptance of proposed Formal Interim Measures action

..... TAA

..... Bridge owner (if different from TAA)

..... Highway Authority (if different from TAA)

7.3 Alternative Other Interim Measures (5.1)
(Note that the need to present such options should be discussed with the TAA)

..... Assessment team for assessing organisation

..... Director / Partner for assessing organisation

7.4 Appraisal of alternative Other Interim Measures (acceptance of appraisals presented)

..... TAA

7.5 Instruction to implement 5.1 option

..... Bridge owner or Highway Authority

Note to Section 7.

1. Assessing organisation will sign at 7.1 (and optionally at 7.3)
2. TAA will sign at 7.2 *or* 7.4
3. Appropriate officer of the Highway Authority or the Bridge Owner (not the TAA) will sign at 7.5
4. Private bridges - Further signatories at 7.2 and 7.5 will permit relevant parties to endorse action to be taken