Design Manual for Roads and Bridges

Highway Structures & Bridges
Inspection & Assessment

CS 470
Management of sub-standard highway structures

(formerly BD 79/13)

Revision 0

Summary
This document sets out the procedures for managing highway structures that have been found to be sub-standard.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	CS 470 replaces BD 79/13. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BD 79/13, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

The purpose of this document is to provide the requirements for the management of highway structures that have either been assessed to be sub-standard according to the requirements of CS 454 [Ref 1.I] or are deemed to be sub-standard by other methods.

Since assessments are typically based on theoretical calculations and the identification of sub-standard structures without completed assessments are typically based on engineering judgement, such structures do not necessarily pose an immediate and unacceptable risk to safety.

The document also provides requirements and guidance on the use of interim measures.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
TAA	Technical Approval Authority

Symbols

Symbol	Definition
γfL	Partial factor for load
γm	Partial factor for material strength
$\gamma f3$	Partial factor for load effect

Terms and definitions

Terms & definitions

Term	Definition
Immediate risk structures	Structures that are considered to represent an immediate and unacceptable safety risk to the public. NOTE Guidance on identifying immediate risk structures is included in Section 3.
Load mitigation interim measures	Interim measures that reduce the effects of the loading on the structure to an acceptable level, either by reducing the magnitude of the loading or by altering the response of the structure. NOTE Examples of load mitigation interim measures include: weight restrictions, lane restrictions, propping, use of a temporary structure and closure.
Low risk provisionally sub-standard structures	Provisionally sub-standard structures that are considered to be low risk and therefore not requiring any interim measures while the assessment is in progress. NOTE Guidance on identifying low risk provisionally sub-standard structures is included in Section 4.

Terms & definitions (continued)

Term	Definition
Monitoring	For the purposes of this document monitoring is defined as the periodic or continuous observation and recording of information pertaining to structural behaviour, in order to detect deterioration or distress if it occurs, to determine the extent, severity and rate of deterioration, and to determine whether a critical limit state or other criteria are at risk of being reached, it would also include the consideration of the likelihood that the hazard can be prevented in response to the detection of early warning signs, where: 1) "Periodic" refers to observations carried out at discrete times with intervals between them measured, in general, in weeks or months; 2) "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; 3) "Observations" are most commonly obtained by visual inspection but they can also include measurement made using transducers, strain gauges, probes or other instruments; 4) "Recording" refers to writing down or mapping information from visual observations, measurements or test data, photography, or the automatic storage of information on charts, printers, magnetic media or other similar; 5) "Information" can be qualitative, such as the presence of staining or other defects, or quantitative, such as the dimensions, locations and patterns of cracks, profile of span, strain or deflection, or readings obtained from non-destructive testing methods; 6) "Deterioration" refers to a decline in condition, integrity or performance arising from any cause (including an aggressive environment, loading, and impact), for example, corrosion-induced spalling, load-induced cracking or changes evidenced by strain/displacement measurement.
Monitoring-appropriate structures	Structures that are considered to be appropriate for monitoring as an interim measure. NOTE Guidance on identifying monitoring-appropriate structures is included in Section 6.
Monitoring interim measures	Interim measures in the form of monitoring alone or monitoring with other measures.
Provisionally sub-standard structures	Structures that are deemed to be sub-standard without an assessment (for examples scour, impact damage, deterioration) or assessed to have sub-standard load capacity at any stage during the assessment process, regardless of whether they are considered appropriate to progress the assessment further.
Risk	An evaluation of the likelihood and consequences of a hazard.

Terms & definitions (continued)

Term	Definition
Sub-standard structures	Structures found to be sub-standard in terms of meeting the carriageway loading requirements given in CS 454 [Ref 1.I] or by other means (as examples by scour, impact damage, deterioration), and retaining walls that have been found to be sub-standard either according to the principles in CS 454 [Ref 1.I] or by other means, after carrying out an appropriate assessment. NOTE The definition of sub-standard structures does not apply to structures with sub-standard non-primary load carrying elements that are not directly affected by carriageway loading (such as sub-standard parapets, and bridge supports at risk from collision).
Terms in "Roles and responsibilities"	Team Leader - as defined in CG 300 [Ref 2.N] Principal – as defined in CG 300 [Ref 2.N] Assessment team leader – as defined in CG 300 [Ref 2.N] Overseeing Organisation – as defined in CG 300 [Ref 2.N] Technical Approval Authority - as defined in CG 300 [Ref 2.N]

1. Scope

Aspects covered

1.1 This document shall be applied for the management of sub-standard structures (see terms and definitions), including highway bridges, retaining walls and other highway structures subject to carriageway loading.

NOTE *A structure where only the verge under accidental wheel loading is sub-standard is generally not classified as sub-standard but this needs to be confirmed with the Technical Approval Authority and/or the Overseeing Organisation.*

1.1.1 The principles and procedures of this document may also be useful and relevant for the following structures which are outside the scope of this document:

1) the management of structures with sub-standard non-primary load carrying elements (including sub-standard parapets and bridge supports at risk from collision);
2) the management of sub-standard structures that do not carry a highway;
3) the management of structures that have been assessed using standards or documents other than CS 454 [Ref 1.I] (for example CS 458 [Ref 5.I]), and found to have insufficient capacity.

Implementation

1.2 This document shall be implemented forthwith on all schemes involving the assessment, design, construction, operation and maintenance of structures on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 1.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 1.N] shall be followed in respect of activities covered by this document.

2. Management processes

Key processes

2.1 Provisionally sub-standard structures and sub-standard structures shall be managed by assessing the risks to public safety associated with their continued use and imposing appropriate interim measures when necessary.

2.2 Load mitigation interim measures shall be urgently imposed on immediate risk structures.

2.3 The risk associated with structures shall be determined based on assessments of structural resistance, taking into account the condition and any damage that has occurred.

2.3.1 Assessment of an existing structure should be carried out in stages of increasing complexity, with the object of efficiently determining its adequacy.

2.3.2 Where an inadequacy of an existing structure is identified in the early stages of an assessment process, the decision whether to continue and complete the assessment should be discussed with the Technical Approval Authority (TAA) and/or Overseeing Organisation.

Document and records management

2.4 For each provisionally sub-standard and sub-standard structure, an auditable record shall be maintained to enable the management of the structure to be clearly documented.

2.5 The record shall include:

1) details of the decisions taken at each stage of the assessment process;
2) evidence of the approval and implementation of any interim measures;
3) documentation of the regular review of the management of the structure.

2.5.1 The record should include the following:

1) documentation of the progress of the assessment and the history of the management of the structure. The sub-standard structure summary form given in Appendix D is to be used to summarise the progress of the assessment process and any interim measures that have been proposed or implemented;
2) risk assessments;
3) assessment of the feasibility, cost and appropriateness of options for interim measures. The forms in Appendices A4 and A5 are to be used to record the feasibility of options for interim measures and to identify immediate risk structures, low risk provisionally sub-standard structures, and monitoring-appropriate structures;
4) record of the decision not to carry out interim measures, if appropriate, including a record of the agreement of the TAA and/or Overseeing Organisation and/or the structure owner where relevant;
5) proposals for interim measures. The form in Appendix A6 is to be used to propose recommendations for interim measures. The proposal is to include an assessment of the feasibility of different interim measures (using Appendices A4 and A5) and details of proposed actions, including the 'monitoring specification' if appropriate (using Appendix A2);
6) approval of interim measures. Documentation of the approval from all required authorities to proceed with the recommended interim measures or details of alternative actions is to be provided, for example by including a copy of the form in Appendix A6 signed by all relevant responsible parties;
7) record of implementation of interim measures;
8) monitoring records/reports, for structures that are being monitored;
9) records of the regular review of interim measures, including the regular review of the management of provisionally sub-standard structures for which no interim measures are in place;
10) record of removal of interim measures;
11) record of strengthening or replacement;
12) these records are to be uploaded onto the Overseeing Organisation's management information system.

3. Immediate risk structures

3.1 Whenever an immediate and unacceptable risk to public safety is identified, the Overseeing Organisation and Technical Approval Authority (TAA) shall be informed without delay.

NOTE 1 *Immediate risk structures can be identified by any competent person.*

NOTE 2 *The identification of immediate risk structures can occur during an assessment, at the completion of an assessment, during an inspection, following an incident such as an accidental event, or at any other time.*

3.2 In assessing immediate risk to public safety, the following factors shall be evaluated:

1) the consequence of failure;
2) nature of the structural weakness;
3) any corresponding signs of distress;
4) the possibility of hidden distress;
5) condition data;
6) the sensitivity of the structure to the applied loading;
7) the recent load history of the structure; and
8) the level of assessment completed.

NOTE *The past performance of the structure under unrestricted loading can inform the assessment of whether an immediate risk is posed.*

3.2.1 Any of the following should be taken to be indicative of an immediate risk structure:

1) any structure that is unable to sustain nominal loading (i.e. the loading according to CS 454 [Ref 1.I] but without any partial load factors applied to live and dead loading) according to any plastic upper bound method of assessment (such as a yield-line mechanism analysis);
   a) structures with primary carriageway elements that have been assessed to have zero live load capacity;
   b) structures with carriageway elements for which the assessed capacity would be insufficient for the required assessment live loading even when all partial safety factors (including all γfL , γm , and $\gamma f3$) are set to unity;
2) any structure that, when the capacity is calculated across the full width of the structure and compared with the load effects assuming that the loads are fully distributed across the full width of the structure, has a corresponding live load capacity factor C (as defined in CS 454 [Ref 1.I]) that is less than $K/\gamma fL$, where K is the required Load Reduction Factor appropriate to the traffic on the structure (as defined in CS 454 [Ref 1.I]) and γfL is the partial factor for the traffic loading;
3) any structure with significant signs of distress associated with either a non-ductile failure mode or the formation of a failure mechanism;
4) any structure with significant damage such that the structure is considered to be at immediate risk of collapse or landslip;
5) any scour-susceptible structure considered to be at immediate risk of collapse.

NOTE *γfL is covered in CS 454 [Ref 1.I].*

Emergency interim measures

3.3 Once confirmed and agreed with the Overseeing Organisation and TAA, appropriate 'load mitigation interim measures' (or, for elements that do not support a carriageway, appropriate interim measures as described in Section 6) shall be implemented as a matter of urgency on any 'immediate risk structure'.

3.3.1 Where there is likely to be a delay in implementing the load mitigation interim measures, a temporary emergency closure may be used to reduce the risks.

3.3.2 Where an emergency interim measure is required to make safe an immediate risk structure, the agreement between the relevant parties should be recorded using the form in Appendix A8.

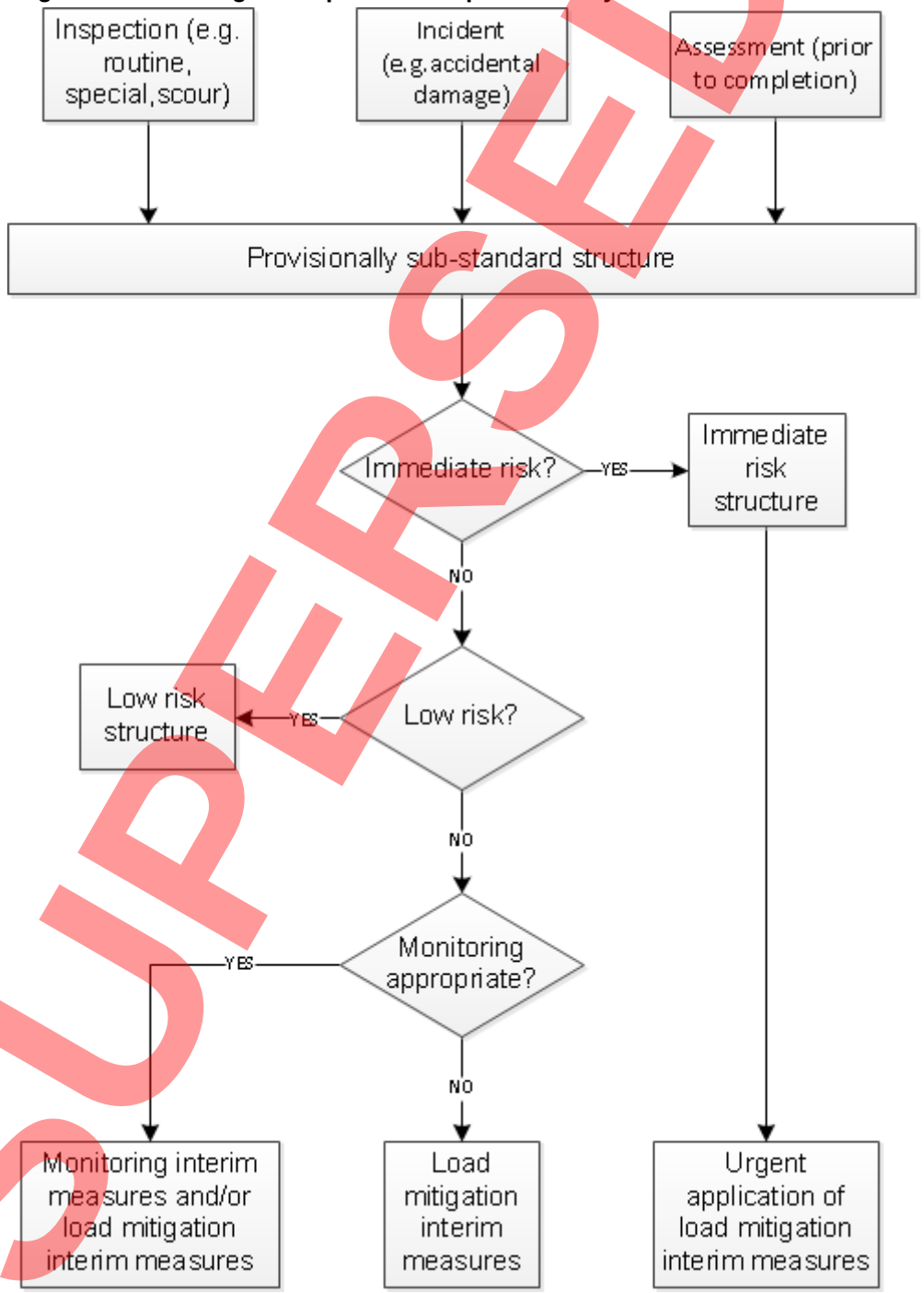
4. Management of provisionally sub-standard structures

4.1 Where a structure is deemed to be a provisionally sub-standard structure, the need for interim measures during the assessment process and the appropriate type of interim measures shall be assessed and recorded.

NOTE 1 *The purpose of the interim measures for provisionally sub-standard structures is to reduce the risks to an acceptable level during the assessment process.*

NOTE 2 *A flowchart outlining the management process for provisionally sub-standard structures is given in Figure 4.1.N2*

Figure 4.1N2 Management process for provisionally sub-standard structures



4.2 Where the structure is an immediate risk structure, load mitigation interim measures shall be urgently imposed.

4.3 Load mitigation interim measures shall be imposed on provisionally sub-standard structures unless it can be shown that the risks during the assessment process can be managed to an acceptable level without imposing interim measures or by using monitoring interim measures.

4.3.1 Provisionally sub-standard structures may be managed without interim measures where:

1) they are not immediate risk structures;
2) it is probable that further assessment could raise the assessed capacity to an acceptable level;
3) it is possible to proceed with this assessment without delay;
4) the decision is agreed with the TAA and/or Overseeing Organisation and/or the structure owner and recorded.

4.3.2 Low risk provisionally sub-standard structure may be managed without any interim measures during the assessment process, provided that such a decision is agreed with the TAA and/or Overseeing Organisation and/or the 'structure owner' where relevant, and recorded.

4.3.3 Where the structure is a monitoring-appropriate structure, the form of interim measures may include monitoring, either with or without load mitigation interim measures.

Low risk provisionally sub-standard structures

4.4 The identification of low risk provisionally sub-standard structures shall be based on an assessment of the risks associated with the continued use of the structure without imposing any interim measures.

4.4.1 Either of the following may be taken to be indicative of low risk provisionally sub-standard structures:

1) structures whose only provisionally sub-standard elements are non-carriageway elements that are only predicted to fail under accidental loading, and where a safety barrier is in place to protect the non-carriageway part of the structure;
2) structures in sound condition for which all of the following conditions apply:
   a) the failure is likely to be gradual over time progressing from local signs of distress (such as cracking or local failure at a connection) to more extensive failure before reaching the point where total collapse is precipitated;
   b) the consequences of failure are low; and
   c) the live load capacity factor is greater than the factored Load Reduction Factor appropriate to the traffic on the structure.

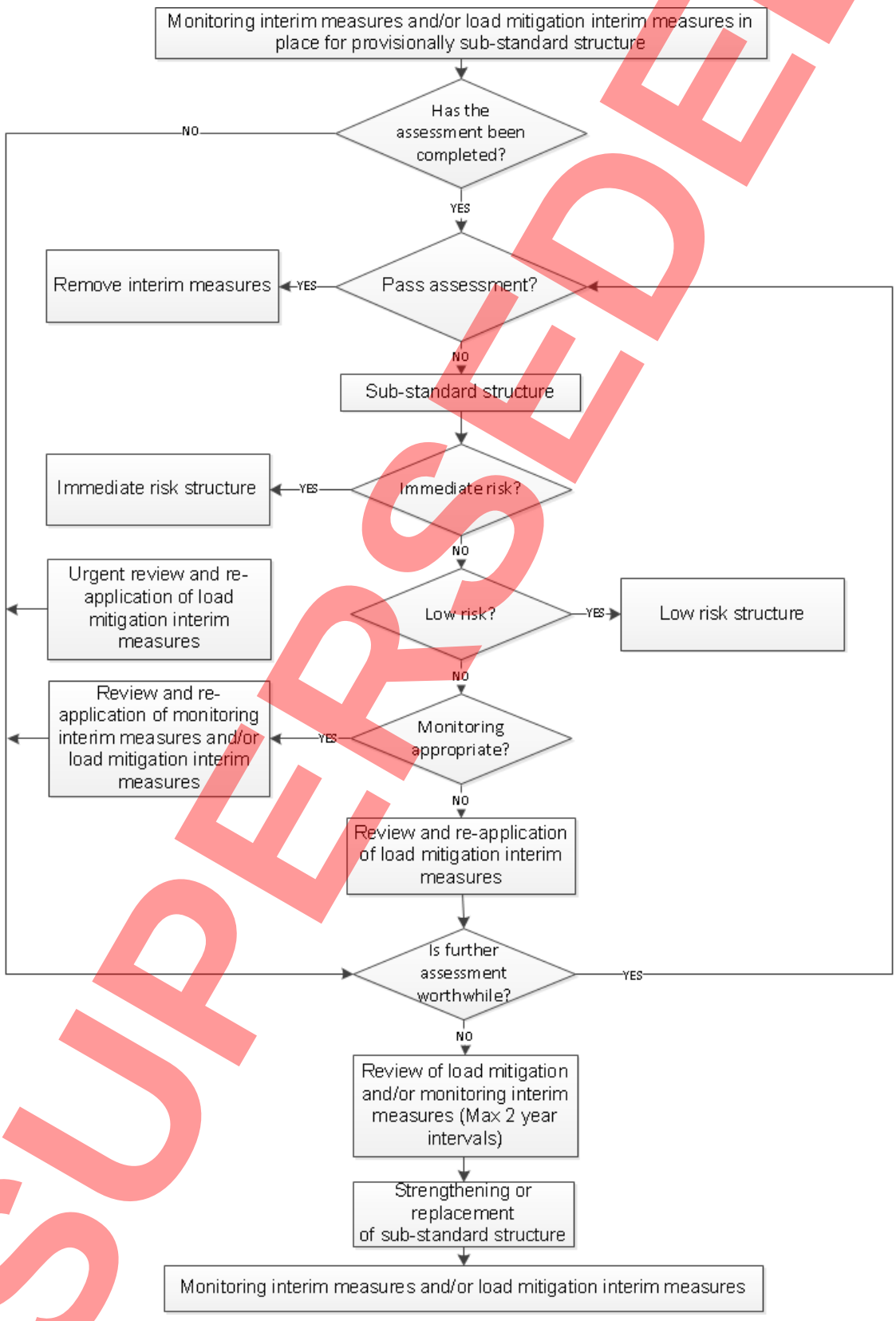
5. Management of sub-standard structures

5.1 Where on completion of the assessment process a structure is found to be a sub-standard structure, interim measures shall be used pending strengthening or replacement of the structure.

NOTE 1 *The purpose of the interim measures for sub-standard structures is to reduce the risks to levels that are acceptable until strengthening or replacement of the structure is carried out.*

NOTE 2 *A flowchart outlining the management process for sub-standard structures is given in Figure 5.1N2.*

Figure 5.1N2 Management process for sub-standard structures



NOTE 3 The assessment process can include a series of assessments with increasing levels of complexity when required.

5.2 The form of the interim measures shall be determined based on an analysis of the effectiveness of the interim measures in reducing risk, and the potential disruption to traffic.

5.2.1 When the structure is a monitoring appropriate structure, monitoring interim measures may be used (with or without load mitigation interim measures) when agreed with the TAA and/or Overseeing Organisation and/or the structure owner where relevant.

5.3 When monitoring interim measures are not used, load mitigation interim measures shall be used on sub-standard structures.

5.3.1 Monitoring on a short-term basis may be used to manage the risk during any delay before the imposition of load mitigation interim measure where it can be shown that it is a suitable approach.

5.4 Sub-standard structures shall be prioritised for strengthening or replacement.

6. Interim measures

Load mitigation interim measures

6.1 Load mitigation interim measures shall reduce carriageway loads, or the effect of the loads, so that they are within the capacity of the structure.

6.1.1 Load mitigation interim measures should comprise one or more of the following actions:

1) vehicle weight restrictions, calculated in accordance with CS 454 [Ref 1.l];
2) lane restrictions, calculated in accordance with CS 454 [Ref 1.l];
3) propping of the structure;
4) use of a temporary structure;
5) closure of the structure to all users or classes of vehicles.

6.2 Where further deterioration of the structure occurs after the application of load mitigation interim measures, the appropriateness of the interim measures shall be reviewed.

6.3 Where the deterioration affects the effectiveness of the load mitigation interim measures, monitoring interim measures shall be used in combination with load mitigation interim measures.

6.4 The planned maximum duration for load mitigation interim measures shall not exceed two years.

6.5 At the end of two years the application of load mitigation interim measures shall be formally reviewed in accordance with clauses 7.1 -7.4.

Existing weight restrictions

6.6 Periodic reviews of weight restrictions shall be carried out at intervals not exceeding two years in accordance with clauses 7.1 – 7.4 until such time that formal approval to maintain the weight limit as a permanent measure is granted by the Highway (or Roads) Authority.

6.6.1 Where an existing weight restriction has been in place for some time, and where periodic reviews confirm that the restriction is effective and of benefit, the structure owner may consider continuation of the measure as a long-term arrangement, with the agreement of the Highway (or Roads) Authority.

6.6.2 The form in Appendix A9 should be used as a mechanism for accepting the weight limit as a permanent measure.

Monitoring interim measures

6.7 Monitoring interim measures shall only be carried out on monitoring-appropriate structures.

6.8 Monitoring interim measures shall comprise either monitoring alone or monitoring with other measures (such as propping or partial restriction of traffic loading).

Monitoring-appropriate structures

6.9 Sub-standard structures that satisfy all the criteria given in (1), (2) and (3) below, shall be considered to be monitoring-appropriate structures, subject to Technical Approval Authority (TAA) and/or Overseeing Organisation approval:

1) structures where no sign of significant distress is observed and hidden distress, deterioration or weakness is unlikely to be present, or structures where distress is observed that 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 (such as cracking or local failure at a connection) to more extensive failure before reaching the point where total collapse is precipitated (in contrast to structures whose mode of failure and collapse under traffic load will be sudden and brittle), and it is 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 (further guidance is given in Appendix A1).

6.9.1 Bridges of small span (generally less than 5m) that are in sound condition and where the consequences of failure are low may also be considered to be monitoring-appropriate structures, subject to Technical Approval Authority (TAA) and/or Overseeing Organisation approval.

NOTE 1 Types of sub-standard structures that are likely to be monitoring-appropriate include:

a) 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;

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

c) structures in which deterioration is gradually progressing and for which monitoring can be used to measure the progression of the deterioration.

NOTE 2 Sub-standard structures that are not normally monitoring-appropriate include bridges that are sub-standard by virtue of tension, shear, anchorage or buckling inadequacies where failure in tension, shear, anchorage or buckling would precipitate collapse of the structure.

6.10 Managing sub-standard structures through monitoring, with or without other measures, shall be undertaken rigorously and using appropriate professional engineering expertise and advice throughout.

NOTE 1 The management of sub-standard structures is a complex process and requires in depth knowledge of the techniques and the potential problems.

NOTE 2 In order to design an effective monitoring and reporting system, it is necessary to understand the likely failure mechanism of the structure.

NOTE 3 Guidance on monitoring is provided in Appendix A1.

6.11 Where monitoring interim measures are used, the monitoring regime shall be documented in a monitoring specification.

6.12 The monitoring specification shall include:

1) a summary of the assessment findings and other background information relating to the appropriateness of the proposed monitoring;
2) a protocol for monitoring, reporting and the escalation of decision making;
3) an emergency response and communication plan, where appropriate and agreed with the Overseeing Organisation, and where sudden deterioration could lead to a structure being classified as an 'immediate risk structure';
4) a detailed plan of the monitoring regime, including the definition of all parameters to be monitored, directly related to the predicted mode(s) of failure, and the degree of accuracy required;
5) the frequency of monitoring;
6) definition of trigger levels;
7) details of any actions to be taken if trigger levels are exceeded;
8) requirements for the recording and reporting of monitoring activities;
9) a plan for the review of the monitoring regime.

6.12.1 The format in Appendix A2 should be used for the monitoring specification.

NOTE Monitoring by itself does not prevent damage from occurring. The longer monitoring is continued, the greater is the possibility of damage, particularly for bridges on heavily trafficked routes.

6.13 A planned maximum duration for the monitoring, not exceeding two years, shall be specified in the monitoring specification.

6.14 Where the monitoring is to be continued after two years, the application of monitoring interim measures shall be formally reviewed in accordance with clauses 7.1 – 7.4.

6.15 Where monitoring interim measures are to be removed whilst the structure remains sub-standard, the form in Appendix A9 shall be submitted to the TAA and/or Overseeing Organisation together with the form in Appendix A6 detailing the alternative interim measures to be put in place.

Certification of interim measures

6.16 The necessity or otherwise of any certification in addition to that described in this document shall be agreed with the TAA and/or Overseeing Organisation.

Emergency response and communications plan

6.17 An emergency response and communication plan shall be maintained for sub-standard structures subject to monitoring interim measures.

6.17.1 The emergency response and communication plan should include:

1) definition of roles and responsibilities;
2) contact details for all parties including out of hours and/or deputies;
3) protocol for monitoring, reporting, trigger level and escalation of decision making;
4) list of senior management for escalation and stakeholders and suppliers to be informed.

6.18 The emergency response and communication plan shall be uploaded onto the Overseeing Organisation's management information system.

Interim measures for non-carriageway parts of structures

6.19 A planned maximum duration for interim measures for non-carriageway parts of structures shall be specified.

NOTE 1 *The planned maximum duration for interim measures can apply to both deck cantilevers as well as non-carriageway parts of beam and slab decks.*

NOTE 2 *For non- carriageway parts of structures, such as cantilevers, it can be more suitable to install an appropriate vehicle restraint, which could be considered as a long-term solution (See CS 454 [Ref 1.I]).*

6.20 At the end of the planned duration for interim measures for non-carriageway parts specified period, the continued application of interim measures shall be formally reviewed.

7. Review of interim measures

Load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures

7.1 Load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures shall be formally reviewed at intervals not exceeding two years if the structure has not been strengthened or replaced.

7.2 Where there is a change in the condition or use of the structure, additional formal reviews shall be undertaken.

7.3 Formal agreement with the continued application of load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures shall be recorded using the form in Appendix A7.

7.4 A copy of the completed form related to the formal agreement of the continued application of load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures shall be uploaded on to the Overseeing Organisation's management information system.

Intervals for reviewing interim measures

7.5 Interim measures shall be reviewed following any condition inspection of the structure.

NOTE *There will be cases where shorter intervals are considered appropriate, based on the condition, use and rate of deterioration of the structure.*

7.6 The assessment team or the organisation responsible for the inspection, management and maintenance of the structure shall monitor, review and propose any required changes to interim measures to the Overseeing Organisation and/or Technical Approval Authority (TAA).

8. Ongoing record-keeping requirements

8.1 For each structure subject to load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures, the documents to be handed over shall include the following where applicable:

1) proposals for interim measures document (completed Appendix A6 form);
2) approval of interim measures document;
3) record of implementation of interim measures;
4) monitoring records/reports, for structures that are being monitored;
5) records of the regular review of interim measures, including the regular review of the management of provisionally sub-standard structures for which no interim measures are in place;
6) risk assessments;
7) monitoring specification;
8) protocol for monitoring, reporting and the escalation of decision making;
9) emergency response and communication plans.

8.1.1 The proposal for interim measures document should include an assessment of the feasibility of different interim measures (see Appendices A4 and A5) and details of proposed actions, including the monitoring specification (see Appendix A2), if appropriate.

8.1.2 Documentation of the approval from all required authorities to proceed with the recommended interim measures or details of alternative actions should be provided, for example by including a copy of the form in Appendix A6 signed by all relevant responsible parties.

8.2 The party handing over responsibility for the continued implementation of the interim measures on a structure shall upload copies of all relevant documents listed in section 8.1 on the Overseeing Organisation's management information system.

NOTE *Handover requirements ensure continuity when responsibility for structures subject to load mitigation interim measures, monitoring interim measures and interim measures for non-carriageway parts of structures are passed from one party to another.*

9. Prioritisation for strengthening or replacement

9.1 The national requirements for prioritisation for strengthening or replacement shall be followed.

NOTE *Please see the National Application Annexes for further details.*

10. Removal of interim measures

10.1 Removal of load mitigation interim measures, monitoring interim measures and/or interim measures for non carriageway parts of structures shall be formally agreed with the Overseeing Organisation and recorded.

NOTE *The removal of interim measures requires formal confirmation that a structure is no longer sub-standard and that it is safe to remove load mitigation interim measures, monitoring interim measures and/or interim measures for non-carriageway parts of structures.*

10.2 A copy of the completed form related to the formal agreement of the removal of load mitigation interim measures, monitoring interim measures and/or interim measures for non carriageway parts of structures shall be uploaded on to the Overseeing Organisation's management information system.

11. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 2.N	Highways England. CG 300, 'Technical approval of highway structures'

12. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	Highways England. CS 454, 'Assessment of highway bridges and structures'
Ref 2.I	The Concrete Society. Concrete Bridge Development Group. CS TG2, 'Guide to testing and monitoring the durability of concrete structures'
Ref 3.I	Highways England. CS 450, 'Inspection of highway structures'
Ref 4.I	Highways England. CS 464, 'Non-destructive testing of highways structures'
Ref 5.I	Highways England. CS 458, 'The assessment of highway bridges and structures for the effects of special type general order (STGO) and special order (SO) vehicles '
Ref 6.I	UKRLG - The UK Roads Liaison Group. WmHI CoP, 'Well-managed Highway Infrastructure - A Code of Practice'

Appendix A. Monitoring of sub-standard structures

A1 General

This appendix gives advice on the application of monitoring. It describes different classes of monitoring for structures found to be monitoring-appropriate in the assessment process and provides guidance on their use.

The purpose of monitoring should be defined; for examples: detecting (and quantifying) damage and deterioration, validating the effect of remedial measures.

The actions to be taken based on the monitoring should be defined; for examples: trigger levels and the actions to be taken, the use of data in supporting analysis.

There are many techniques and instruments available for monitoring with differing capabilities and limitations. As new monitoring techniques and instruments become available, careful appraisal of their benefits/disbenefits should be undertaken prior to their use.

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.

The class and type of monitoring should be appropriate for the likely failure mechanism of the structure (or part of structure to be monitored).

At the lowest level monitoring may be limited to visual inspection and recording information.

All highway structures are, as a minimum, subjected to basic visual inspections ('general inspections') every two years and more detailed inspections ('principal inspections') normally every six years at intervals described in CS 450 [Ref 3.I] but see also 'Well-Managed Highway Infrastructure – A Code of Practice' (WmHI CoP [Ref 6.I]).

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 and reported to the structure owner to determine the next course of action.

The extent of monitoring will depend on the type of structure, its condition, current circumstances, load mitigation interim measures proposed, the assessed structural inadequacies and likely failure mechanism.

The monitoring should be continued until the structure has been strengthened or replaced, or load mitigation interim measures have been implemented.

In some cases it may be appropriate to monitor in conjunction with load mitigation interim measures.

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

Types of inadequacy that may be inherent in a sub-standard structure include the following:

1) the assessment calculations indicate that the load carrying capacity is inadequate because the original design loading was lower than that now required, and/or other principles and criteria used in the original design were less onerous than those now adopted for assessment;
2) there was 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 was used. The structure was not formally designed for any traffic loading.

Two or more of these types of inadequacy may be present in combination. For structures falling within scope of 1 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 1, the assessment calculations provide the basis for identifying the critical areas for monitoring.

Any of the inadequacies described 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; for examples in the webs of contiguously placed beams, under the surfacing in hogging regions, at half joints or hinges. Such possibilities together with information on other forms of deterioration should be taken into account when planning a monitoring scheme.

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 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. For example, 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.

An essential starting point in considering whether to implement a monitoring regime for a structure is the criteria for monitoring-appropriate structures given in section 6. Other key issues to be considered are:

1) the structure's specific purpose;

2) what events, distress or deterioration may possibly occur;

3) the ability to observe these events and the consequences should they not be detected;

4) the accuracy and relevance of the observations; and

5) the costs and disruption incurred in obtaining data.

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, are unlikely to invalidate monitoring provided their significance and effects can be accounted for.

Potential modes of collapse, in particular progression from local failure and ductility, 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 as part of the justification for the implementation of a monitoring regime, there should be no weak links in the redundant path.

When attempting to foresee possible modes of failure it should be borne in mind that the C factor (see CS 454 [Ref 1.I]) 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 that a sudden mode of failure has not been overlooked.

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 load mitigation 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.

A1.1 Classes of monitoring

A principal objective of all classes of monitoring is the detection of deterioration in structural behaviour or condition, should it occur. It may also be used to confirm structural behaviour under live load. The monitoring regime for a structure should be defined in detail in each specific case. A monitoring specification is required as described in section 6 and Appendix A2. The three monitoring classes described below 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.

For all classes of monitoring, if deterioration occurs, the cause, severity and extent should be identified.

A1.1.1 Class 1 – Basic monitoring

Class 1 monitoring consists of visual observations and recording.

The use of photography is essential. Measurements are not normally undertaken, but the condition of the critical parts of the structure should be noted and compared with previous records.

Inspection at touching distance is normally required, although for some structures the use of binoculars may be appropriate, with the agreement of the Technical Approval Authority (TAA) and/or Overseeing Organisation. Simple operations, such as hammer tapping to check for delamination or loose members, may be included. Recording of traffic flows and composition may also be required.

Observations for Class 1 monitoring should be at intervals of weeks or months and should therefore be more frequent than for a structure that meets the requirements of CS 454 [Ref 1.I].

A1.1.2 Class 2 – Detailed monitoring

Class 2 monitoring includes the visual observations and photographic provisions of Class 1, supplemented as appropriate by one or more of the following:

1) recording of quantitative information which may include: the extent and nature of deterioration; (as examples, the locations and dimensions of areas affected); the length, width, depths and spacing of cracks; a level survey repeated periodically; and non-destructive testing. Reference may be made to DMRB document CS 464 [Ref 4.I] and 'Technical Guide 2: Guide to testing and monitoring the durability of concrete structures' CS TG2 [Ref 2.I];
2) measurement of changes in parameters such as displacement or strain at typical or critical positions in cases including those where visual inspection alone is not sufficient to confirm that there is no change in the structural action, structure condition, or response to traffic loading. Parameters to be monitored may include measurements to detect changes in permanent or transient effects, so monitoring may need to be continuous, instantaneous or maximum/minimum. (It is emphasised that the use of the word typical here refers to a situation in which, for instance, one typical beam might be monitored from a multi-beam span, or one typical span monitored from a multi-span deck, to act as a check on the progression of any distress. If undue distress is observed the situation should be reviewed, additional monitoring may be necessary or 'load mitigation interim measures' may be required);
3) 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;
4) extended traffic loading survey, as appropriate.

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.

A1.1.3 Class 3 – Extensive monitoring

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.

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.

A1.2 Selection of appropriate monitoring class

The following discussion, which is not exhaustive, indicates some of the important factors that may need to be considered in defining the monitoring regime for a particular sub-standard structure. Some specific guidance is given for flexural and shear inadequacies, and for masonry arch structures. In all cases, if deterioration occurs, the level of monitoring should be reviewed.

A visual inspection regime (Class 1) will be sufficient in many cases to give an adequate assurance of safety. Structures having a sound structural form with no significant defects or signs of distress but which have been assessed to be sub-standard are typical 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 show visual signs of increasing distress over a period of (at least) several weeks as traffic continues to use the bridge, then a visual inspection regime may be appropriate.

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.

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 forewarning of collapse.

Class 3 monitoring will normally be required on a structure where it is necessary to allow a higher level of loading than that given in the assessment standards 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.

A1.3 Sub-standard bridges with flexural inadequacies

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

1) 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;
2) bridges where there is a theoretical flexural inadequacy that 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; that is, 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.

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. For concrete structures, difficulties arise where the tension fibre cannot be observed, such as the top surface of a built-in slab, portal or box culvert.

This could lead to a requirement for a higher level of monitoring, say Class 2, with, for example, strain gauges attached in typical positions to detect any reduction in flexural stiffness that could indicate cracking on the concealed surface. Alternatively instrumentation could be placed on the concealed surface. However, for concrete structures, 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.

For some concrete structures, there may be the potential for a more sudden type of flexural failure with less displacement and cracking, for example, older prestressed structures that contain little reinforcing steel or structures with inadequate laps or anchorages.

The margin between the cracking moment and the ultimate moment should also be considered since it indicates the potential for warning signs to be observed. In rare cases the ultimate moment could be less than the cracking moment.

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.

Wide bridges that carry several lanes are statistically less likely to fail suddenly and catastrophically in flexure under traffic loading than a single-lane bridge for which one vehicle could cause a loading event of significantly greater magnitude than the bridge had previously experienced. For wide bridges the maximum loading is more likely to build up gradually over time if local traffic conditions change and failure generally has to occur over the full width if collapse is to take place.

Narrow, 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 such structures a higher level of monitoring may be appropriate including frequent visual inspection or instrumentation to detect progression of distress.

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.

A1.4 Sub-standard bridges with shear inadequacies

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:

1) visible flexural cracking would precede shear distress and act as an early warning; or
2) inclined cracks would occur on surfaces that can be observed.

For monitoring to be appropriate, there has to 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 concrete bridges with shear inadequacies are not suitable for monitoring when C for shear is less than 0.55K, and not when it is less than 0.66K (see CS 454 [Ref 1.I]) 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.

A1.5 Sub-standard masonry arch bridges

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 that adequate signs of distress will arise under high vehicle load sufficient to forewarn of vulnerability to collapse. The following factors should be considered in establishing whether monitoring is appropriate and if it is, the necessary level of monitoring:

1) the presence and effect of strengthening features that have not been accounted for in the assessment such as internal walls, robust spandrel/wing walls;
2) the load history of the structure, if known, particularly if the structure has previously carried heavy loads;
3) the type of arch ring and its influence on observable deterioration. For examples, for dressed stone masonry would defects be visible?; for a multi-ring bridge is hidden ring separation present?; for rubble masonry is deterioration obscured?;
4) the arch ring shape and its potential for sudden collapse, considering, for examples, whether it is circular or elliptical, its span-to-rise ratio, and the effect of haunching;
5) the condition of the foundations and the potential for movement to produce sudden failure. Could a saddle have increased the eccentricity of thrust there may be an additional risk when defects have been subjected to cosmetic repairs that conceal faults, for example the detachment of a spandrel wall or arch ring separation;
6) the type and nature of existing defects, which may indicate the potential for sudden collapse;
7) the modes of deterioration, considering how the progression of such deterioration may be effectively monitored.

A2 Monitoring specification

The monitoring regime for each sub-standard structure should be specified in a clear, unambiguous monitoring specification. The specification should include the following (unless the monitoring is intended merely to check that load mitigation interim measures are continuing to function satisfactorily):

A2.1 Background

This section should include a summary of the relevant information included in the interim measures feasibility assessment (see Appendix A4 and A5). In particular, it should include a summary of the following:

1) assessment findings. The basis of the assessment inadequacy, stated clearly and concisely. Generic reasons such as 'flexure' or 'shear' are not sufficient: the location, nature, degree and underlying reasons should be stated, and the live load capacity factor C and the required Load Reduction Factor K for the existing traffic and road surface category given (see CS 454 [Ref 1.I]). When there are several inadequacies, each should be described and an overview given. The level of assessment undertaken should also be stated;
2) deterioration of structure. A review of existing information on the causes, extent and severity of any deterioration together with the expected progression of the deterioration;
3) service performance. An appraisal of the reasons for the observed satisfactory service performance: for example, low load levels, conservative structural model; conservative resistance model, resistance enhancement;
4) anticipated failure mode(s). The anticipated mode(s) of failure together with an indication of the likelihood and consequences of such failure.

A2.2 Monitoring plan

This section should include a detailed statement of the planned monitoring regime. All parameters to be monitored should be related to the predicted mode(s) of failure and progression to that state, together with the required accuracy of observation. Specific reference should be made, where appropriate, to the following:

1) visual observations;
2) measurements;
3) photographs. A description of the location from which photographic records should be taken, and/or a sample photograph;
4) other parameters. A description of any other parameters to be monitored.

A2.3 Monitoring frequency

This section should include a detailed statement of the frequency of monitoring.

A2.4 Monitoring trigger levels

This section should include a description of the ranges of observations which are acceptable and the values, or other features, which constitute trigger or warning.

Levels requiring action: It is sometimes helpful to identify intermediate levels, for example, a red-amber green system may be used.

A2.5 Monitoring trigger actions

This section should include a clear set of procedures to be implemented if trigger 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.

A2.6 Recording and reporting

This section should include clear guidelines on the recording and reporting of monitoring activities, for example including, where appropriate, the use of standardised reporting forms, filing systems and/or electronic databases, and requirements for reporting to the Technical Approval Authority (TAA).

A2.7 Review of monitoring requirements

This section should include provisions for regular review of the monitoring regime, its planned maximum duration (see section 6.12.1 – 6.14), and also any procedures following observed behaviour of the structure, such as an increased or reduced monitoring frequency.

A2.8 Protocol for monitoring, reporting and the escalation of decision making

This section should include the protocol for monitoring, reporting and escalation of decision making including a definition of roles and responsibilities, contact details for all parties including out of hours and/or deputies and a list of senior management for escalation.

A2.9 Emergency response and communication plan

This should include the protocol for emergency response and communication, contact details for all parties including out of hours and/or deputies and a list of senior management for escalation and stakeholder suppliers to be informed.

NOTE 1 The monitoring specification should be developed following a special inspection unless recent inspection records are adequate for the purpose.

A3 Sub-standard structure summary

The form set out below provides a model for recording the progress of the assessment process in accordance with section 2.5.1. The form should be used to record any changes in the status of the sub-standard structure. A sample completed form is included to illustrate its application.

Table A.1 Sample form - Sub-standard structures status summary sheet

Structure Name:						
Structure Ref. No.:						
Assessment/ Review	Stage:	Level 1 Assessment				
	Date:					
	Report reference:					
	Assessed capacity:					
	Sub-standard status:					
Interim Measures Feasibility Assessment	Date:					
	Is the structure an Immediate Risk structure or a low risk provisionally sub-standard structure?					
	Is the structure monitoring appropriate?					
Interim Measures Proposal	Date:					
	Recommendations:					
Interim Measures Approval	Date:					
	Approval/Rejection:					
Actions	Implementation date:					
	Details/ref.:					
	Provisional finish date for monitoring:					
	Removal date:					
Documentation	Form used:					
	Date:					
Additional Notes						

Table A.2 Sample completed sub-standard structures status summary sheet

	Stage:	Level 1 Assessment	Level 2 Assessment	Level 3 Assessment	Interim Measures Review	Strengthening Feasibility
Assessment/ Review	**Date:**	01/05/06	01/08/06	01/12/06	01/11/08	01/01/10
	Report reference:	43216/AR1	43216/AR2	43216/AR3	43216/MR8	43216/SFR1
	Assessed capacity:	18 tonnes	26 tonnes	26 tonnes	26 tonnes	26 tonnes
	Sub-standard status:	Provisionally Sub-standard	Provisionally Sub-standard	Sub-standard	Sub-standard	Sub-standard pending strengthening
Interim Measures Feasibility Assessment	**Date:**	08/05/06	08/08/06	08/12/06	01/11/08	N/A
	Is the structure an Immediate Risk Structure or a Low Risk Provisionally Sub-standard Structure?	Low Risk Provisionally Sub- standard Structure	Low Risk Provisionally Sub-standard Structure	No	No	N/A
	Is the structure 'Monitoring appropriate'?	Monitoring appropriate structure	Monitoring appropriate structure	Monitoring appropriate structure	Monitoring appropriate structure	N/A
Interim Measures Proposal	**Date:**	08/05/06	08/08/06	12/12/06	01/11/08	01/01/10
	Recommendations:	No interim measures proposed.	No interim measures proposed.	Load Mitigation IM: Weight restriction 26 tonnes, or Monitoring IM: see Monitoring Spec. 43216/MS1	Weight restriction 26 tonnes, with continued monitoring.	Strengthen structure with FRP
Interim Measures Approval	**Date:**	22/05/06	22/08/06	05/01/07	15/11/08	N/A
	Approval/ Rejection:	TAA approval of lack of IM	TAA approval of lack of IM	Monitoring IM approved	Weight restriction and monitoring approved	N/A

Table A.2 Sample completed sub-standard structures status summary sheet (continued)

	Stage:	Level 1 Assessment	Level 2 Assessment	Level 3 Assessment	Interim Measures Review	Strengthening Feasibility
Actions	**Implementation date:**	22/05/06	22/08/06	01/02/07	01/12/08	June 2010
	Details/ref:	No IM imposed. Assessment to progress to Level 2	No IM imposed. Assessment to progress to Level 3MR8	See Monitoring Spec and Monitoring Reports 43216/ MR 1-43216	Restriction sign, purchase order: PO4 3216-1. Monitoring reports 43 216/MR9-13. Prioritise for strengthening	Structure strengthened see design drawings 43216/FR P/DR101- 102, and specification 43216/FRP/SP1
	Provisional finish date for monitoring:	N/A	N/A	01/02/10	N/A	N/A
	Removal date:	N/A	N/A	30/06/10	30/06/10	N/A
Documentation	**Form used:**	Appendix A4	N/A	Appendix A6	Appendix A7	Appendix A9
	Date:	22/05/06	N/A	01/02/07	01/12/08	June 2010
Additional notes		Low Risk Provisionally Sub-std. Structure: no IMs required. Considered likely that a refined structural model could improve assessment capacity	Low Risk Provisionally Sub-std. Structure: no IMs required. Considered appropriate to progress to Level 3 assessment	Monitoring details given in monitoring spec. Planned duration of monitoring 2 years	Monitoring trigger-levels exceeded – weight restriction introduced, in combination with continued monitoring. Strengthening prioritised.	Structure strengthened for full design loading. Structure no longer sub-standard

A4 Interim measures feasibility assessment for bridges

NOTE 1 To be completed when a potentially sub-standard structure is identified.

A4.1 GENERAL DETAILS

A4.1.1 Structure name and assessment reference:

1) Structure Ref No:

NOTE 2 HA Form 277 or Overseeing Organisation's equivalent information to be attached.

A4.1.2 Location, route and county/area:

A4.1.3 Assessing Organisation:

1) Assessed by:
2) Checked by:
3) Assessment date:

A4.1.4 Structure type, form, span, skew:

A4.1.5 Obstacle crossed and facility carried:

A4.1.6 Estimated cost of permanent strengthening/replacement works:

A4.2 ASSESSMENT PROGRESS

A4.2.1 Level of assessment reached:

A4.2.2 Assessed capacity:

A4.2.3 Date of assessment:

A4.2.4 Assessment Report reference:

A4.2.5 Provisionally Sub-standard or Sub-standard?

A4.2.6 Description of anticipated mode of failure, including its progressions from local overstress to global collapse mechanism:

A4.2.7 Description of distress (if present):

A4.3 CONSIDERATION OF RISK POSED BY STRUCTURE IN CURRENT STATE

A4.3.1 3.1 Discussion

NOTE 3 Section to include discussion of likelihood and consequence of collapse, likelihood of warning signs, degree of safety implied by latest assessed capacity.

1) Is the structure an immediate risk structure?
2) Is the structure a low risk provisionally sub-standard structure ?

A4.4 APPROPRIATENESS OF MONITORING

A4.4.1 Discussion

NOTE 4 Section to include discussion of:

1) distress;
2) redundancy, ductility, predictability;
3) risk (likelihood and consequence);
4) effectiveness and meaningfulness of monitoring.

A4.4.2 Is the structure monitoring-appropriate?

A4.5 OPTIONS FOR LOAD MITIGATION INTERIM MEASURES

A4.5.1 Option Title

NOTE 5 For each option, the following issues should be considered:

1) operational and cost implications;
2) other implications.

A4.6 OPTIONS FOR MONITORING INTERIM MEASURES

A4.6.1 Option Title

NOTE 6 If the structure is monitoring-appropriate, for each option, the following issues should be considered:

1) description of monitoring regime;
2) effectiveness of monitoring regime with reference to anticipated failure mode;
3) risk of collapse;
4) risk of damage at loads lower than the collapse load;
5) operational and cost implications;
6) other implications.

A4.7 RECOMMENDED OPTIONS FOR INTERIM MEASURES

A4.7.1 Recommended Load Mitigation Interim Measures:

A4.7.2 Recommended Monitoring Interim Measures:

A5 Interim measures feasibility assessment for retaining walls

NOTE 1 To be completed when a potentially sub-standard structure is identified.

A5.1 GENERAL DETAILS

A5.1.1 Structure name and assessment reference:

Structure Ref No:

NOTE 2 HA Form 277 or Overseeing Organisation's equivalent information to be attached.

A5.1.2 Location, route and county/area:

A5.1.3 Assessing Organisation:

Assessed by:

Checked by:

Assessment date:

A5.1.4 Estimated cost of permanent strengthening/replacement works:

A5.2 DEFORMATION DESCRIPTION:

A5.2.1 Bulging:

A5.2.2 Tilting:

A5.2.3 Sliding:

A5.3 EXTENT OF DEFORMATION:

A5.3.1 Height and width of deformation:

Maximum retaining height of wall: m

Average retained height of wall: m

A5.3.2 Deviation from line vertical:

A5.4 HISTORY:

A5.4.1 General Inspection or Principle Inspection references to deformation:

A5.5 CONSIDERATION OF RISK POSED BY STRUCTURE IN CURRENT STATE

A5.5.1 Discussion

NOTE 3 Section to include discussion of likelihood and consequence of collapse, likelihood of warning signs, degree of safety implied by latest assessed capacity.

A5.5.2 Is the structure an Immediate Risk Structure?

A5.5.3 Is the structure a Low Risk Provisionally Sub-standard Structure ?

A5.6 APPROPRIATENESS OF MONITORING

A5.6.1 Discussion

NOTE 4 Section to include discussion of

1) distress;
2) redundancy, ductility, predictability;
3) risk (likelihood and consequence);
4) effectiveness and meaningfulness of monitoring.

A5.6.2 Is the structure monitoring-appropriate?

A5.7 OPTIONS FOR LOAD MITIGATION INTERIM MEASURES

Option Title

For each option, the following issues should be considered:

1) operational and cost implications;
2) other implications.

A5.8 OPTIONS FOR MONITORING INTERIM MEASURES

A5.8.1 Option Title

NOTE 5 If the structure is monitoring-appropriate, for each option, the following issues should be considered:

1) the history of deformation;
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;
4) description of monitoring regime;
5) effectiveness of monitoring regime with reference to anticipated failure mode;
6) risk of collapse;
7) risk of damage at loads lower than the collapse load;
8) operational and cost implications;
9) other implications.

A5.9 RECOMME NDED OPTIONS FOR INTERIM MEASURES

A5.9.1 Recommended Load Mitigation Interim Measures:

A5.9.2 Recommended Monitoring Interim Measures:

A6 Proposal for interim measures

A6.1 GENERAL DETAILS

A6.1.1 Structure name and assessment reference:

Structure Ref No:

NOTE 6 Form 277 or equivalent information to be attached.

A6.1.2 Location, route and county/area:

A6.1.3 Assessing Organisation:

Assessed by:

Checked by:

Assessment date:

A6.1.4 Structure type, form, span, skew:

A6.1.5 Obstacle crossed or facility carried:

A6.1.6 Estimated cost of permanent strengthening/replacement works:

A6.2 PROPOSED INTERIM ME ASURES

A6.2.1 Summary of assessment progress.

A6.2.2 Summary of feasibility of options for Interim Measures (details attached as an appendix).

A6.2.3 Summary of Recommended Load Mitigation Interim Measures (details attached as an appendix, if appropriate) including maximum duration and date for formal review.

A6.2.4 Summary of Recommended Monitoring Interim Measures, if appropriate (refer to Monitoring Specification, attached as an appendix) including maximum duration and date for formal review.

A6.2.5 Proposal made by:

..... Date:

..... Assessment Team Leader

..... Date:

..... Principal

A6.3 ACCEPTANCE OF INTERIM MEASURES

A6.3.1 Appraisal of recommended Load Mitigation Interim Measures and Monitoring Interim Measures (if appropriate)

..... Date:

..... TAA and/or Overseeing Organisation

NOTE 1 TAA and/or Overseeing Organisation to sign to confirm that recommended Load Mitigation Interim Measures and Monitoring Interim Measures have been appraised and their technical efficacy agreed.

..... Date:

..... Team Leader

A6.3.2 Acceptance of Load Mitigation Interim Measures (if required)

NOTE 2 Highway (or Roads) Authority acceptance is only necessary where the accepted interim measures affect the traffic on the highway network.

..... Date:

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

A6.3.3 Instruction to implement Interim measures

Interim Measures to be implemented:

NOTE 3 Overseeing Organisation and/or Structure Owner to instruct which option for interim measures is to be implemented and to sign to endorse action to be taken.

..... Date:

..... Overseeing Organisation and/or Structure Owner (Additional Signatories)

NOTE 4 Additional signatories may be required to permit additional relevant parties to approve, endorse or instruct action to be taken, for example, where the responsibility for the implementation and/or the cost of interim measures is shared between parties. Such requirements need to be agreed between the relevant parties.

A7 Review of interim measures

A7.1 GENERAL DETAILS

A7.1.1 Structure name and assessment reference:

Structure Ref No:

NOTE 1 HA Form 277 or Overseeing Organisation's equivalent information to be attached.

A7.1.2 Location, route and county/area:

A7.1.3 Assessing Organisation:

Assessed by:

Checked by:

Assessment date:

A7.1.4 Structure type, form, span, skew:

A7.1.5 Obstacle crossed or facility carried:

A7.1.6 Estimated cost of permanent strengthening/replacement works:

A7.2 EXISTING INTERIM MEASURES

A7.2.1 Summary of existing Load Mitigation and/or Monitoring Interim Measures (details attached as an appendix if appropriate) including maximum duration and date for formal review.

A7.2.2 Details of any changes to the structure since the implementation of Load Mitigation and/or Monitoring Interim Measures (including but not restricted to structure condition, structure usage, structure loading).

A7.2.3 Summary of recommended action (if continuation of existing load mitigation and/or monitoring interim measures is recommended, include maximum duration and date for next formal review).

A7.2.4 Proposal made by:

..... Date:

..... Team Leader

..... Date:

..... Principal:

A7.3 ACCEPTANCE FOR CONTINUATION OF INTERIM MEASURES

A7.3.1 Acceptance of recommended Load Mitigation and/or Monitoring Interim Measures (if appropriate)

..... Date:

..... TAA and/or Overseeing Organisation

NOTE 2 TAA and/or Overseeing Organisation to sign to confirm that recommended Load Mitigation Interim Measures and Monitoring Interim Measures have been appraised and their technical efficacy agreed.

..... Date:

..... Team Leader

A7.3.2 Acceptance of continuation of Load Mitigation and/or Monitoring Interim Measures (if required)

NOTE 3 Highway (or Roads) Authority acceptance is only necessary where the accepted interim measures affect the traffic on the highway network.

..... Date:

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

A7.3.3 Instruction to implement Interim Measures

Interim Measures to be implemented:

NOTE 4 Overseeing Organisation and/or Structure Owner to instruct which option for interim measures is to be implemented and to sign to endorse action to be taken.

..... Date:

..... Overseeing Organisation and/or Structure Owner (Additional Signatories)

NOTE 5 Additional signatories may be required to permit additional relevant parties to approve, endorse or instruct action to be taken, for example, where the responsibility for the implementation and/or the cost of interim measures is shared between parties. Such requirements need to be agreed between the relevant parties.

A8 Immediate risk structure: Emergency action record of agreement/incident log

Immediate Risk Structure

Proposals for Emergency Action

Record of Agreement/Incident Log

Date:

Table A.3 Record

Structure Name	
Roads affected	
Comment on CS 470 procedures	
Brief description of need	
Emergency Action (include timescale for undertaking action)	
Additional comments(include a brief explanation as to why the particular emergency action was chosen)	

The above emergency proposals are agreed by:

Table A.4 Signatures

Signature:	Signature:
Name:	Name:
Representing:	Representing:
Date:	Date:
Signature:	Signature:
Name:	Name:
Representing:	Representing:
Date:	Date:

A9 Interim measures removal

A9.1 GENERAL DETAILS

A9.1.1 Structure name and assessment reference:

Structure Ref No:

NOTE 1 HA Form 277 or Overseeing Organisation's equivalent information to be attached.

A9.1.2 Location, route and county/area:

A9.1.3 Structure type, form, span, skew:

A9.1.4 Obstacle crossed or facility carried:

A9.2 PROPOSAL TO REMOVE EXISTING INTERIM MEASURES

A9.2.1 Summary of existing Load Mitigation and/or Monitoring Interim Measures (details to be attached as an appendix if appropriate).

A9.2.2 Summary of proposal to remove existing Load Mitigation and/or Monitoring Interim Measures (to include details of completed strengthening and/or replacement works to be attached as an appendix if appropriate).

or

A9.2.3 Summary of justification to make the weight limit a permanent measure and no longer subject to periodic reviews.

A9.2.4 Proposal made by:

..... Date:

..... Team Leader

..... Date:

..... Principal

A9.3 ACCEPTANCE FOR REMOVAL OF INTERIM MEASURES

A9.3.1 Appraisal of recommended removal of Load Mitigation and/or Monitoring Interim Measures (if appropriate)

..... Date:

..... TAA and/or Overseeing Organisation

NOTE 2 TAA and/or Overseeing Organisation to sign to confirm that recommended removal of Load Mitigation and/or Monitoring Interim Measures have been appraised and their technical efficacy agreed.

..... Date:

..... Team Leader

A9.3.2 Acceptance to remove Load Mitigation and/or Monitoring Interim Measures (if required)

NOTE 3 Highway (or Roads) Authority acceptance is only necessary where the removal of interim measures affect the traffic on the highway network.

..... Date:

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

A9.3.3 Acceptance to remove Interim Measures

NOTE 4 Overseeing Organisation and/or Structure Owner to endorse action to be taken.

..... Date:

..... Overseeing Organisation and/or Structure Owner (Additional Signatories)

NOTE 5 Additional signatories may be required to permit additional relevant parties to approve, endorse or instruct action to be taken, for example, where the responsibility for the interim measures is shared between parties. Such requirements need to be agreed between the relevant parties.

A10 Documentation of management processes

Documentation of management processes.

Table A.5 Documentation of management processes

Process	Recommended approach for reporting	Reference
Identification of Immediate Risk Structure Figure 4.1 Flowchart for managing provisionally sub-standard structures figure	Interim Measures Feasibility Assessment Emergency action record of agreement	Bridges: Appendix A4 to Section A5.5 Retaining Walls: Appendix A5 to Section A5.5 Appendix A8
Identification of Low Risk Provisionally Sub-standard Structure Figure 4.1 Flowchart for managing provisionally sub-standard structures figure	Interim Measures Feasibility Assessment	Bridges: Appendix A4 to Section A4.3 Retaining Walls: Appendix A5 to Section A5.6
Identification of Monitoring-appropriate structure Figure 4.1 Flowchart for managing provisionally sub-standard structures figure	Interim Measures Feasibility Assessment	Bridges: Appendix A4 to Section A4.4 Retaining Walls: Appendix A5 to Section A5.6
Interim measures for non-monitoring-appropriate structures Figure 4.1 Flowchart for managing provisionally sub-standard structures figure	Interim Measures Feasibility Assessment Interim Measures Proposal Form	Bridges: Appendix A4 to Section A4.5 Retaining Walls: Appendix A4 to Section A5.7 Appendix A6
Interim measures for Monitoring-appropriate structures Figure 4.1 Flowchart for managing provisionally sub-standard structures figure	Interim Measures Feasibility Assessment Interim Measures Proposal Form Monitoring Specification	Bridges: Appendix A4 to Section A4.7 Retaining Walls: Appendix A5 to Section A5.9 Appendix A6 Appendix A2
Review of interim measures Figure 5.1 Flowchart for managing sub-standard structures	Review of Interim Measure Form	Appendix A7
Removal of interim measures Figure 5.1 Flowchart for managing sub-standard structures	Interim Measure Removal Form	Appendix A9

Highway Structures & Bridges
Inspection & Assessment

CS 470
England National Application Annex to CS 470 Management of sub-standard highway structures

(formerly BD 79/13)

Revision 0

Summary
This National Application Annex sets out Highways England's specific requirements on prioritisation for strengthening or replacement of sub-standard structures.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	Highways England National Application Annex to CS 470.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes part of BD 79/13, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This National Application Annex gives the Highways England-specific requirements related to the management of substandard structures.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

E/1. Prioritisation for strengthening or replacement

E/1.1 The strengthening or replacement of sub-standard structures shall be prioritised, whilst ensuring public safety and preventing loss of use of the structures by maintaining appropriate interim measures.

E/1.1.1 The strengthening or replacement of a sub-standard structure may take several years.

E/1.1.2 Value management techniques may be useful for the prioritisation of strengthening works.

NOTE *Reference can be made to 'Well-managed highway infrastructure - A Code of Practice' WmHI CoP [Ref 1.I].*

E/1.2 Prioritisation of strengthening work to sub-standard structures shall take into account:

1) the relative risks of the structures to public safety, taking account of the effectiveness of the interim measures (including monitoring only), reserves of strength, and the causes, severity, extent and rate of deterioration and its consequences;
2) the specified maximum intended duration for monitoring 'interim measures';
3) the traffic delay costs that are caused by the implementation of interim measures, and which will be eliminated when the strengthening or replacement is complete;
4) 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;
5) the risks and other issues associated with alternative routes (including winter conditions and other route-related considerations);
6) the whole-life cost-effectiveness of the strengthening, taking into account the ratio of costs and benefits, and the residual life of the structure;
7) other benefits which will result from the work such as improvements to sight lines and parapets, general repairs and preventative maintenance; and
8) strategic development of the highway network.

E/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

E/3. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	UKRLG - The UK Roads Liaison Group. WmHI CoP, 'Well-managed Highway Infrastructure - A Code of Practice'

Department for Infrastructure
An Roinn Bonneagair

Highway Structures & Bridges
Inspection & Assessment

CS 470
Northern Ireland National Application Annex to CS 470 Management of sub-standard highway structures

(formerly BD 79/13)

Revision 0

Summary
This National Application Annex sets out the Department for Infrastructure Northern Ireland's specific requirements on prioritisation for strengthening or replacement of sub-standard structures.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

This is a controlled document.

Contents

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Version	Date	Details of amendments
0	Mar 2020	Department for Infrastructure Northern Ireland National Application Annex to CS 470.

Foreword

Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

This document supersedes BD 79/13, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This National Application Annex gives the Department for Infrastructure Northern Ireland-specific requirements related to the management of sub-standard highway structures.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

NI/1. Scope

NI/1.1 In Northern Ireland the process of prioritisation for strengthening or replacement shall be in accordance with Department for Infrastructure Policy.

NI/1.2 In Northern Ireland the process for managing sub-standard bridges with spans of 10m cumulative or less shall be in accordance with Department for Infrastructure Policy.

NI/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

Highway Structures & Bridges
Inspection & Assessment

CS 470
Scotland National Application Annex to CS 470 Management of sub-standard highway structures

(formerly BD 79/13)

Revision 0

Summary
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CS 470.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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Contents

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0	Mar 2020	Transport Scotland National Application Annex to CS 470.

Llywodraeth Cymru
Welsh Government

Highway Structures & Bridges
Inspection & Assessment

CS 470
Wales National Application Annex to CS 470 Management of sub-standard highway structures

(formerly BD 79/13)

Revision 0

Summary
There are no specific requirements for Welsh Government supplementary or alternative to those given in CS 470.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

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