

HIGHWAYS AGENCY
CONTRACT 2/419 TECHNICAL AUDIT OF THE APPLICATION OF BA79

TECHNICAL AUDIT OF BA79 – THE MANAGEMENT OF SUB-STANDARD STRUCTURES

Final Project Report

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EXECUTIVE SUMMARY

In November 1987 the then Minister for Roads and Traffic announced a 15-year programme of bridge rehabilitation ("the bridge programme") with the aim of bringing road structures up to current standards. The programme comprised three main sub-programmes, of which assessment and strengthening was one.

One particular aspect of the assessment and strengthening sub-programme was the management of structures which were found to be sub-standard following assessment, either in the interim while further assessment work was undertaken or at the end of the assessment when theoretical assessment methods had been exhausted and strengthening or replacement options were being developed.

A National Working Group, chaired by the Highways Agency (HA) and including representatives from major bridge owners in the UK, was subsequently set up to provide advice which led to the publication in 1998 of BA79 - The Management of Sub-standard Structures.

In August 2002 Parsons Brinckerhoff Ltd was appointed to review the use of BA79 to identify anomalies and deficiencies within the current system and ensure that the continuing operation and management of sub-standard highway structures is carried out in a safe manner.

The results of the project indicate that there was significant variability in the level of implementation of BA79 throughout the bridge owners audited and there were an appreciable number of sub-standard structures for which there was no evidence of them being managed either in strict compliance with or in the spirit of the advice note. A number of these structures were being managed by organisations where its use would appear to be mandatory.

If these results are a true reflection of the entire UK it can be deduced that an appreciable percentage of bridge owners/managers do not implement BA79, neither in strict compliance nor in the spirit of the advice note. Therefore, in the absence of contradictory information, it is only possible to conclude that where they have sub-standard structures they are not always managing the risk of collapse in a safe and auditable manner.

In addition, where sub-standard structures are being managed, the quality of documentation of the management process and the base data on which the management strategy is based are variable.

Therefore it appears that the greatest level of risk in the management of sub-standard structures stems from this lack of consistency and limited application of the document, and the quality of the records on which the management processes are based, rather than the technical quality of its application.

It is recommended therefore that BA79 would benefit from significant revision, rather than minor piecemeal changes to individual sections of text. The primary recommendations stemming from this study are:

- that BA79 should be re-drafted into a process-driven departmental standard (BD) as opposed to the current procedurally-driven advice note (BA), thereby encouraging wider and more consistent implementation.
- that as an aid to the management process, each sub-standard structure should be provided with a dedicated management file to provide a single source of information documenting all management actions from the day it is first identified as being provisionally sub-standard through to when it is no longer deemed sub-standard, by means of more advanced assessment, strengthening or replacement etc.

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This report was prepared by Parsons Brinckerhoff Ltd under contract to the Highways Agency.

Both Parsons Brinckerhoff Ltd and the Highways Agency would like to thank all those organisations and individuals who gave so freely of their time by:

- responding to the questionnaire,
- providing data on their sub-standard structures,
- agreeing to be interviewed and
- allowing the audit teams access to their structural records.

It is recognised that without their cooperation, this project could not have been successfully completed.

1 BACKGROUND

In November 1987 the then Minister for Roads and Traffic announced a 15-year programme of bridge rehabilitation (“the bridge programme”) with the aim of bringing road structures up to current standards. The programme comprised three main sub-programmes, of which assessment and strengthening was one.

Originally the assessment and strengthening sub-programme only covered structures on the motorway and trunk road network, but following discussions between Local Authorities and Central Government was extended to cover the entire UK road bridge stock.

Where structures failed their initial assessment there was a requirement to undertake further investigations and further assessment calculations. The complexities of the further work varied from structure to structure.

One particular aspect of the assessment and strengthening programme was the management of structures which were found to be sub-standard following assessment, either in the interim while further assessment work was undertaken or at the end of the assessment when theoretical assessment methods had been exhausted and strengthening or replacement options were being developed.

A National Working Group, chaired by the Highways Agency (HA) and including representatives from major bridge owners in the UK, was subsequently set up to provide advice which led to the publication in 1998 of BA79 - The Management of Sub-standard Structures.

2 SCOPE

In August 2002 Parsons Brinckerhoff Ltd (PB) was appointed to review of the use of BA79 to ensure that the continuing operation and management of sub-standard highway structures is carried out in a safe manner. The scope of the appointment included a survey of the interpretation and implementation of BA79 on a representative sample of sub-standard structures from the following bridge-owners:

- The Highways Agency (HA)
- The Scottish Executive Enterprise, Transport and Lifelong Learning Department (SEETLLD)
- Welsh Assembly Government (WAG)
- The Department for Regional Development for Northern Ireland (DRDNI)
- A number of local authorities (LAs).

The aim of the audit of BA79 was to identify anomalies and deficiencies within the current system, and not to check or verify the accuracy of assessment records or calculations. Consequently, all reporting within the project was carried out on a non-attributable basis.

3 OBJECTIVES

The objective of the audit of BA79 was to review and evaluate the application of BA79 in the management of sub-standard highway structures, encompassing bridges, retaining walls and other highway structures and their structural components such as piers, foundations and abutments, where appropriate. It's aim was to identify what techniques are being used, where, and if there is scope for further developments to improve its safe and effective application.

4 METHODOLOGY

The project adopted a multi-phase approach, with each phase comprising different aspects.

4.1 Phase 1

The objectives of phase 1 of the commission were to:

- Develop an understanding of any areas of concern or issues associated with BA79 from a broad range of bridge owners and managers.
- Establish a database of sub-standard structures including those managed to BA79, by bridge owner.

The above objectives were achieved through the following tasks.

4.1.1 Questionnaire

A questionnaire was produced to develop an understanding of any areas of concern or issues associated with the application of BA79. The format and composition of the questionnaire was based upon the content and layout of BA79 with comments sought from both Lancashire County Council and WAG prior to final submission to HA for approval prior to issue.

It was recognised that any concerns or issues associated with the application of BA79 would most likely differ between organisations and geographic regions. Therefore the questionnaires were distributed to a wide range of organisations specifically selected to ensure coverage throughout the UK bridge owning/management community. A summary of the number distributed and returned is given in Table 4.1.

Organisation	No. Questionnaires	
	Distributed	Returned
HA Technical Approval groups & Managing Agents	10	6
Devolved Authorities	3	2
English Local Authorities	24	14
Welsh Local Authorities (including Trunk Road Agents)	9	5
Total	46	27

Table 4.1 – Questionnaire distribution

On return the results were collated into an electronic database, specifically developed for the purpose to facilitate efficient analysis and reporting. The results of the returned questionnaires have been used to develop the points presented in section 5 onwards and are summarised on a non-attributable basis in Appendix A

4.1.2 Data collection

Bridge owners/managers were also contacted to request the information required to further develop a database of sub-standard structures to be used to inform the audit selection process.

For their sub-standard structures, they were requested to provide the information presented in Table 4.2.

- Structure No
- National Grid Reference
- Year commissioned
- Is the structure on a heavy load route?
- Design load
- Design standard (and version)
- Any special design loading
- Type of deck construction
- Form of deck
- Nature of end supports
- Nature of intermediate supports
- Nature of foundations
- Assessment rating
- Assessment standard (and version)
- Level of assessment (as defined in BA79)
- Reason for deficiency
- Is the structure managed to BA79?
- Are interim measures in place?

Table 4.2 – Structural information requested

In general, due to the nature of each organisation's bridge management system they were unable to provide all the data in the form requested. More commonly, PB was provided with the bridge name and number, date of construction (where known), the type of deck construction and the assessment rating¹.

The distribution of requests for the information and the responses received is shown in Table 4.3.

Organisation	No. requests for info	
	Submitted	Returned
7 No HA MAs	7	7
Devolved Authorities	3	3
Local Authorities	15	6
Total	25	16

Table 4.3 – Information on sub-standard structures

¹ Any missing information was collected during the phase 2.

4.2 Phase 2

The objectives of phase 2 of the commission were to:

- Investigate particular issues of concern with the management of BA79 amongst the UK bridge management community
- Investigate the approach to the management of BA79 taken by UK bridge managers, based on the technical audit of the management of a representative sample of sub-standard structures

The above objectives were achieved through the following tasks.

4.2.1 Selective interviews

Upon receipt of the questionnaire data, it was apparent that although differences in opinion did exist about specific points there was a general consensus regarding the application of BA79. It was therefore decided that the most appropriate next step would be to investigate key aspects in more detail via face-to-face interviews with various individuals within the bridge management community.

A total of 7 interviews were carried out and the individuals selected encompassed both trunk road and local authority bridge owners. In the case of the trunk road network, those interviewed were from client organisations, rather than their managing agents.

The structure of each interview was tailored to take into account each individual's response to the questionnaire, responses to the questionnaire from the wider bridge community, and the results of the technical audits (section 4.2.2) that were being carried out in parallel. However, care was taken to ensure that there was sufficient flexibility to investigate any additional issues raised during the discussion

In addition to the formal interviews, where possible, informal discussions also took place during the course of the audits between the auditor and those involved in managing their respective bridge stocks on a day-to-day basis.

All interviews/discussions were undertaken on a non-attributable basis and therefore the discussions are not directly reported within this report. However, the views expressed are incorporated at the relevant point within the discussions in section 5 onwards.

4.2.2 Technical audit

4.2.2.1 Data sampling

Upon receipt of the data from bridge owners it was collated into an electronic database. The database was purpose-developed to facilitate the selection of a representative sample of sub-standard structures for audit. The selection process was designed to ensure all major forms of construction/structure types were represented as were a wide range of bridge owners.

Each of the structures selected for audit was assigned an audit category to signify their presence on the *primary* audit list. The remaining structures were assigned to a *secondary* list to indicate that they would only be audited if one of the structures in the primary selection proved to be unsuitable or if there was additional time available during the audit to increase the sample number.

4.2.2.2 Audit database

In order to facilitate data collection and maximise efficiency, a further database was developed to record the results of each structure audit. The database incorporated the following key features:

- User friendly interface to minimise the learning curve associated with its use
- Standards menus, pull-downs etc. to make data entry efficient and reporting consistent
- Assigned data fields to enable all data described in the project brief to be collected and analysed, together with additional data fields to facilitate the capture of any relevant supplementary information to meet the wider aspirations of the brief.
- Pre-populated with data on sub-standard structures supplied by co-operating bridge owners/managers.

4.2.2.3 Auditor training

Prior to the audits being undertaken, all auditors took part in a full day training session. The training day covered the following aspects:

- The structure and content of BA79
- Database operation
- Audit procedures

The need for this training was to ensure that the data collected was both as accurate and consistent as possible.

4.2.2.4 Audit visits

Each individual structure audit involved a review of all available records on the structure related to the assessment process and its subsequent management following a failed assessment. Depending on the bridge authority the records could either be in paper form (ie. the contents of the traditional “structure file”), in electronic form (ie. the “bridge database”, spreadsheets, scanned and electronically stored copies of the historic paper records), or a combination of the two.

In the majority of cases the review of documentation was sufficient to identify how a particular structure was being managed. However, in some cases, where there was some uncertainty, it was necessary to follow up specific issues with the bridge management staff for clarification.

Each audit team consisted of between 2 and 4 auditors, the number being tailored to suit the requirements of the bridge owner, the number of structures in the sample and the time available to carry out the audit.

Each auditor was equipped with a laptop computer containing an individually numbered copy of the database. By numbering each copy it was possible to carry out internal quality reviews of the data being collected and, during the subsequent data analysis stage, clarify any areas where the data was unclear.

Each team was also equipped with portable hand-held scanning devices to allow copies of individual documents to be taken. In these cases the co-operating body was informed of the possible need to take copies of various documents in advance and their agreement sought. The type of documents copied tended to fall into the following categories:

- Different examples of BA79 proforma
- Examples of risk assessments to identify monitoring frequency/strengthening priority

A total of 19 audit visits were undertaken encompassing a range of trunk road and local road network bridge owners² which resulted in a total of 444 structures being audited and 37,330 items of data being collected.

On review it was noted that a significant percentage of the structures audited were no longer sub-standard, although they had been sub-standard in some respect according to their last documented assessment. Although not requiring management under BA79, their previous treatment was deemed to be of interest to the study and they were not removed from the data sample. However, there were also a number of structures that did not appear to be sub-standard in any respect (according to their last documented assessment). It was also noted that a number of the structures were outside the remit of the assessment programme, but for differing reasons had been assessed and failed. All these structures were removed from the analysed data set, resulting in a total of 402 being available for analysis.

Network Type	No structures audited	%
Motorway and trunk roads	205	51
Local roads	197	49
Total	402	100

Table 4.4 – Summary of audit statistics

4.3 Limitations of the methodology

As is demonstrated in the previous sections, great care was taken to ensure that the information collected was as accurate and consistently reported as possible. However, it is important to acknowledge the following limitations.

4.3.1 Selection of organisations to be interviewed/audited

The organisations interviewed and/or audited were essentially selected by either their willingness or, in the case of Trunk Road Agents, the willingness of their Overseeing Organisation to participate in the project.

It is believed that those organisations that have chosen not to implement a management regime for sub-standard structures are less likely to have returned their questionnaire and/or agreed to be audited/interviewed. Therefore it can be assumed that in some aspects the data presented in this study is likely to give a more positive picture with regard to the management of sub-standard structures than is the case in reality.

² In Northern Ireland, the NIRS is responsible for both the “local” and “trunk” road networks. Audited NIRS structures were allocated to either the local or trunk road structures based on the category of the road being supported and the obstacle being crossed.

4.3.2 Availability of records

Each audit involved a review of all relevant documentation available on a particular structure. In an ideal situation each structure to be audited would have had a full complement of documentation including (where appropriate):

- Original/contemporary design documentation
- Principal Inspection reports
- Special Investigation reports
- Test Reports
- Assessment Approval in Principle
- Assessment report
- Assessment and Check certificates
- AHS/2i & 2ii forms³
- Proforma in accordance with BA79
- BA79 Monitoring specification/records
- Strengthening Approval in Principle

In reality, the full complement of documentation was rarely, if ever, available. In some circumstances the documents had been lost over time or perhaps never existed in the first instance. On other occasions, although the documentation was in existence it had been removed from the central store for use elsewhere, say where a strengthening scheme was being designed at a remote location. In some rare circumstances the data, usually BA79 monitoring records, were unavailable purely because they were not kept with the main bridge files and the person responsible for that aspect of the management process was not present in the office at the time of the audit and nobody else knew where they were kept. Table 4.5 summarises the availability of various types of key information during the audits.

Documentation	% Available during audit		Comments
	Yes	No	
Original/contemporary design documentation	11	89	Both motorway and trunk road, and local road networks
Principal inspection report	73	27	Both motorway and trunk road, and local road networks
Assessment Approval in Principle	54	46	Both motorway and trunk road, and local road networks
Assessment report	84	16	Both motorway and trunk road, and local road networks
Assessment and Check certificates	63	37	Both motorway and trunk road, and local road networks
AHS/2i & 2ii forms	37	63	Motorway and trunk road network only
Proforma in accordance with BA79	21	79	Both motorway and trunk road, and local road networks

Table 4.5 – Summary of documentation availability statistics

Consequently, on some occasions it was necessary to make assumptions as to how the management processes were being implemented based on the best available data.

³ Only used on the Motorway and Trunk Road network

4.3.3 Available audit time

In order to minimise the level of inconvenience experienced by the bridge owners, it was necessary to carry out the audits so that, in the majority of cases, each audit visit was concluded in one or two days. It was also necessary to limit the size of the audit team to that which could physically be accommodated at the bridge owner's premises.

These requirements coupled with the need to collect a statistically robust sample of data meant that the audit of each individual structure was time constrained. Therefore where a particular piece of information was not apparent from the available documentation and could not be resolved through a discussion with the bridge management staff, it was not possible to carry out a full in-depth investigation to establish further details or information, and consequently judgements had to be made based on the best available data.

5 CONSISTENCY AND LEVEL OF RISK ASSOCIATED WITH THE IMPLEMENTATION OF BA79

The definition of a 'sub-standard' structure varied between organisations. Some considered that a sub-standard structure is one that does not comply with the loading requirements given in BD21. In other instances some organisations chose to include structures whose parapets and/or piers were unable to resist the impact loading requirements given in BD52 and BD48 respectively. This variation in approach is demonstrated in the information supplied by the various organisations as summarised in Table 5.1, based upon the results of the last documented assessment⁴.

Sub-standard to	Motorway and trunk roads	Local roads	All Structures
BD21 only	147	195	342
BD21 & BD48	11	0	11
BD21 & BD52	6	1	7
BD21, BD48 & BD52	3	0	3
BD48 only	18	0	18
BD52 only	16	1	17
BD48 & BD52	4	0	4
Total	205	197	402

Table 5.1 – Summary of sub-standard structures according to the last documented assessment

The definition of sub-standard structures given in BA79 is:

“Structures found to be inadequate in terms of meeting the loading requirements and principles given in BD21”

This definition is reinforced by the Formal Interim Measures identified within the documentation, which by implication are primarily focussed towards ensuring that the structure is capable of carrying normal vehicular traffic, in essence HA loading either on the carriageway or verges/central reservations etc. However, in some cases it would appear likely that clauses 5.9 – 5.11 of BA79, in addition to referring to verges etc have also been interpreted to include both sub-standard piers and parapets.

In response to the above, unless stated to the contrary, all the statistics presented hereafter consider only structures that are specifically sub-standard to BD21.

5.1 Level of compliance to BA79

Of those organisations responsible for the day-to-day management of highway structures⁵ that returned questionnaires, 100% stated that they use BA79 as part of their bridge management regime in some form and 43% implemented it in full.

If it is assumed that those bridge owners who chose not to respond to the questionnaire did not implement BA79, either in full or in part, then only 62% use BA79 in some form and 27% in full. This more pessimistic view is further reinforced by the comments of one bridge manager who,

⁴ As identified previously, a number of these structures have since been strengthened, replaced etc. and are no longer sub-standard.

⁵ Defined as those with day-to-day direct responsibility for the management of structures, ie. excluding “client” organisations.

from discussions with other neighbouring bridge managers, thought that only around 10% of the bridge owners in his region implemented BA79 in its current form.

It is likely that the true situation lies somewhere between these two views.

Of the structures audited, and of those that are currently sub-standard to BD21⁶, 22% were assessed as being managed strictly according to BA79. Another 41% were deemed to be managed “in the spirit of” BA79. This left 37% that were deemed as not being managed to BA79. The definitions used to categorise the level of compliance were as follows:

- Managed to BA79 - documentary evidence of the management process was present, primarily in the form of a BA79 proforma,
- Managed to the spirit of BA79 - evidence of management was identified, such as references to the imposition of interim measures in other reports (eg. subsequent Principal Inspection reports), but there was no BA79 proforma present,
- Not managed to BA79 – No BA79 proforma or evidence of interim measures being implemented.

Table 5.2 splits this data further into those whose last documented assessment is pre and post 1998, the year BA79 was issued. The issue of the document appears to have resulted in an improvement in the way sub-standard structures are managed. The effect is minor on the local road network, where the use of BA79 is only advisory, but, as would be expected, is far more pronounced on the motorway and trunk road network where its use is mandatory.

Managed to BA79	Motorway and trunk roads		Local roads		All structures	
	pre 1998	post 1998	pre 1998	post 1998	pre 1998	post 1998
Yes	31%	77%	0%	0%	13%	32%
in the spirit of	22%	5%	58%	63%	43%	39%
No	47%	18%	42%	38%	44%	30%
Number in sample	72	61	95	88	167	149

Table 5.2 – Level of compliance to BA79

It should be noted that although the results could be construed to indicate that there are no sub-standard structures on the LA road network being managed strictly to BA79, it is known that a number of LA bridge owners do use BA79 proformas, albeit modified to suit their own management structure. However, these bridge owners did not form part of the audit sample.

Recognizing the limitations of the methodology referred to in sections 4.3.2 and 4.3.3, had more information and time been available, it may have been possible to re-categorize a number of the structures deemed as not being managed to BA79, with a consequential increase in those managed in the spirit of BA79. It is also possible that auditing the entire stock of sub-standard structures from each participating organization, rather than a selection, would have had a similar effect.

5.2 Selection of interim measures

Of the structures identified as currently being sub-standard to BD21 and managed to or in the spirit of BA79, a wide number of potential approaches to management have been adopted, their relative level of incidence being demonstrated in Table 5.3.

⁶ Excluding those in the data sample which although sub-standard according to their last documented assessment have been strengthened, re-decked or replaced in the meantime.

As might be expected the incidence of formal interim measures, such as closure, lane width restrictions, propping and vehicle weight restrictions are relatively small, with by far the most popular being monitoring.

After monitoring, the second most frequently used measure on the trunk road network is the use of 'partially effective barriers' to protect non-carriageway parts of the structure. It is interesting to note that no occurrences of this approach were identified on the local road network, although the data indicated that there were some 11 sub-standard structures that could be assigned the full 40 tonne rating if barriers were installed and a further 9 where the load rating could be partially increased.

Interim measures	Motorway and trunk roads ⁷	Local roads	All structures
Closure	1%	0%	1%
Closure & Monitoring	1%	0%	1%
Lane restrictions	5%	2%	5%
Lane restrictions & Monitoring	5%	2%	2%
Monitoring	36%	74%	52%
Other ⁸	8%	0%	4%
Partially effective barriers	15%	0%	7%
Propping	2%	1%	2%
Propping & Monitoring	7%	0%	3%
Temporary bridge	1%	0%	1%
Temporary bridge & Monitoring	2%	0%	1%
Vehicle weight restrictions	8%	10%	14%
Vehicle weight restrictions & Monitoring	8%	11%	7%

Table 5.3 – Summary of interim measures applied

5.3 Monitoring

As demonstrated in section 5.2, the use of monitoring either in isolation or in combination with other measures is by far the most commonly used method of managing sub-standard structures. However, as is recognised in BA79, ensuring the safety of a sub-standard structure through monitoring is a very complex process and requires an in-depth knowledge of its structural behaviour. The following sections investigate some of the key aspects in determining whether monitoring is being carried out appropriately.

5.3.1 Definition of monitoring appropriate

Appendix D of BA79 goes into some depth into the definition of 'monitoring appropriate', but in general it is stated that the following structures are likely to meet the relevant criteria:

⁷ The motorway and trunk road category of bridges includes over bridges carrying local roads and accommodation bridges etc.

⁸ A programme of research was undertaken to investigate the shear resistance of a number of similar structures that had inadequately anchored reinforcement. The research indicated that they had higher shear capacities than was indicated by the relevant code, but there was no evidence of the structures being re-assessed taking into account the data (as a departure from standard). Therefore for the purposes of this project it was necessary to consider them as being sub-standard.

- Reinforced concrete slab bridges or composite steel and composite 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 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 sound condition and where the consequences of failure in terms of death and injury or traffic delay costs etc. are low.

Those 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”.

As demonstrated by the remainder of Appendix D in BA79, it is recognised that in reality the situation is more complex, but using the above basic criteria as a guide, all the currently sub-standard structures were assigned a category identifying whether they were deemed monitoring-appropriate or not.

Table 5.4 indicates the number of sub-standard structures being managed through monitoring alone, and whether they were deemed monitoring appropriate. In general, the results indicate that the advice given in BA79 is being adhered to. There are possibly some structures (19-25 in number) that may be being monitored inappropriately, but it is possible that if each individual case was examined in greater detail, it may be possible to revise this assessment.

Monitoring appropriate	No structures being monitored
No	19
Not clear	4
Yes	89
Total	112

Table 5.4 – Classification of the monitored appropriateness of monitored structures

5.3.2 Appropriateness of the monitoring

Appendix D of BA79 provides guidance on whether a structure is likely to be technically ‘monitoring appropriate’. However, a further criterion introduced earlier in the document in clause 6.6(3) helps determine whether a structure should be monitored, and this criterion is whether the monitoring proposed is both meaningful and effective.

Table 5.5 summarises the 112 structures that were being managed through monitoring alone in terms of the class of monitoring. By far the most commonly used class of monitoring is Class 1, primarily consisting of “visual observations and recording, including photography”.

Class of monitoring	No structures
1	108
2	2
3	2
Total	112

Table 5.5 – Summary of monitoring class

Appendix C of BA79 states that a visual inspection regime (Class 1) is likely to be sufficient for monitoring appropriate structures if the structure is sound with no signs of distress. Table 5.6 indicates the relative incidence of the various types of distress of those structures sub-standard to BD21 being managed solely using Class 1 monitoring. It can be seen that the majority of structures had no visible signs of distress and, although some did, the majority of causes tend to progress slowly and are easily measurable.

Type of distress	% managed solely by Class 1 monitoring
No Distress	60
Bulging	5
Corrosion	2
Distortion	1
Flexural Cracking	5
General Cracking	7
Inadequate Pointing	5
Loss of section	9
Multiple	1
Settlement	2
Spalling	2
Tilting	2
Number in sample	108

Table 5.6 – Relative incidence of distress for structures managed solely by Class 1 monitoring

5.3.3 Frequency of monitoring

Appendix C of BA79 states that the frequency of monitoring should be as follows:

Class 1 – “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 requirement of BD21”

Class 2 – “depending on the bridge, from periodic visits at intervals of several months, to more frequent visits or to continuous monitoring”

Class 3 – “frequent or continuous”

Table 5.7 shows the relationships between the classes of monitoring and the frequency of inspection for all the sub-standard structures managed solely by monitoring. This highlights that a high percentage of structures are only being examined once every one or two years, essentially during either superficial or general inspections. Although there is no maximum frequency specified in BA79 for any of the classes of monitoring, it would appear that monitoring so infrequently is not within the spirit of the advice note and does pose the question whether the inspection covers just the normal scope of a superficial or general inspection, or whether specific care is taken to examine the structure for signs that the identified structural inadequacy is causing distress.

Monitoring frequency (weeks)	Monitoring class		
	1	2	3
Weekly	0%	0%	50%
Monthly	3%	0%	0%
Quarterly	25%	0%	0%
Every 4 months	7%	0%	0%
Biannually	18%	0%	0%
Annually	18%	100%	0%
Every 2 years	20%	0%	0%
Continuous	0%	0%	50%
Not known (no monitoring specification /records)	9%	0%	0%
Number in sample	108	2	2

Table 5.7 – Frequency of monitoring

5.3.4 Monitoring specification

Within Appendix C of BA79, it is stated that for each sub-standard structure being managed through monitoring, a clear, unambiguous procedural document should be prepared detailing the monitoring specification. Unless the monitoring is merely intended to check that other forms of interim measures are continuing to function satisfactory, the document should contain the following:

- The basis of the assessment inadequacy, clearly and concisely stated
- An appraisal of the reasons for the observed satisfactory service performance
- The anticipated mode of failure
- A description of the parameters to be monitored and their relationship to the predicted mode of failure and progression to that state, together with their required frequency of observation and frequency of monitoring
- A description of the ranges of observations which are acceptable and the values, or other features which constitute alarm or warning levels requiring action
- A clear set of procedures to be implemented if alarm or warning levels are reached
- Recording and reporting requirements
- Provision for review of the monitoring regime or procedures following observed behaviour of the structure.

Although 112 structures were identified as being solely managed through monitoring and there were additional structures managed using monitoring in combination with other interim measures, the audit teams were only able to find a very small number of examples of this type of documentation.

Example of monitoring specifications, of the form described within Appendix C, were only found in two organisations, although a number of others did produce a significantly less comprehensive specification which tended to be included as part of the actual monitoring record sheet.

In the majority of cases the only information provided on monitoring was usually found on the BA79 proforma, and where the organisation had chosen not to use a proforma, there was no way of determining what type and frequency of monitoring was being undertaken, other than looking at any available monitoring records.

It is believed that the lack of a monitoring specification brings the following dis-benefits, which have implications for the safe management of sub-standard structures:

- bridge inspectors are less likely to be able to target the focus of their monitoring to particular areas of structural inadequacy
- bridge inspectors are less likely to be aware of what range of observations are acceptable
- bridge inspectors/engineers are less likely to have or be aware of what procedures should be followed if the observations are not deemed acceptable
- in the case of the motorway and trunk road network, information is more likely to be lost on a change of managing agent. This is particularly relevant where monitoring is by means other than visual inspection, where any development work carried out by the managing agent could be deemed to be Intellectual Property.

5.4 Availability of bridge records

Both prior to and throughout the audits, the quality and availability of the necessary information was not always adequate to identify with certainty the current status of a specific structure. This lack of information reduced the efficiency and accuracy of the audit process, but far more importantly this data is also needed to provide the basis of any management regime. The need to keep accurate records is particularly relevant in today's climate where turnover of staff and, in some circumstances complete re-structuring/re-organisation of management arrangements, is the norm, which means the retained knowledge held by individual engineers cannot be relied upon to be available when required. The following sections highlight some of the issues identified.

5.4.1 Asset databases

Many organisations rely on the data contained on their asset database as the primary source of data when managing their stock. Therefore it is important that this data is a true reflection of the bridge stock. However, on a number of occasions it was found that the data contained on such databases did not tally with either the available documentation and/or the belief of the local bridge engineer whose responsibility the structure was.

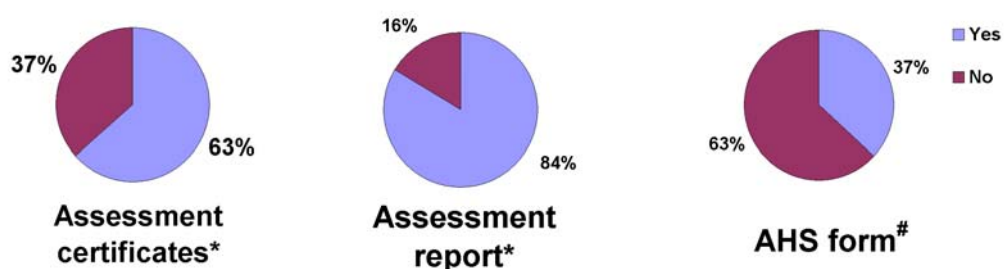
In one notable example, there was sufficient doubt as to the quality of the data supplied by one organisation that it was deemed necessary to carry out a full review of the information prior to carrying out the audit. The result was that of the list of 171 sub-standard structures supplied, some 54 were no longer managed by the organisation, another 28 were no longer sub-standard having been strengthened or replaced, but another 42 new structures were identified as sub-standard in their place.

On other occasions the discrepancies identified were far fewer in number. In the majority of cases they were simply attributed to a data inputting error, usually due to use of inexperienced

non-technical staff to interpret the results of reports and transfer the information to the database. In fact following one particular audit, the bridge owner was able to increase the load capacity on two of his sub-standard bridges.

5.4.2 Assessment ratings

One of the primary key pieces of data in the management process is the assessment rating. This information can be found in one of a number of pieces of documentation; namely the assessment report, assessment/check certificates, and in the case of certain bridge owners AHS forms. Figure 5.1 demonstrates the availability of these pieces found during the audits and illustrates that this key data is not always available. In turn this forces the engineer to rely heavily on the contents of the asset database, which as has already been identified may not always be correct.



* - based on all structures

- based on motorway and trunk road structures only

Figure 5.1 – Availability of assessment data documentation

5.4.3 Implementation of interim measures

During the majority of the audits it was not possible to identify any direct confirmatory evidence that the interim measures proposed had been implemented. BA79 proformas, where they exist, only record the approval process, but do not actually confirm that the measures has been implemented.

In many cases where 'physical' measures had supposedly been implemented, without physically visiting each structure in turn, the only recourse was to look at recent Principal Inspection reports for evidence (eg. the presence of weight restriction signs in photographs etc), but where this was not possible or did not provide the necessary evidence it was necessary to accept the information provided.

In the case of monitoring, where there are generally no physical signs that it is being undertaken, adequate records are essential to document the process. It is believed that the primary reason for the lack of records on some structures was that they were being incorporated into the annual superficial and two-yearly general inspections and therefore the detailed monitoring was either not being undertaken or not being recorded.

5.4.4 Strengthening works

For sub-standard structures that had been strengthened there was rarely any confirmation that it had been carried out. Occasionally, an AIP would be present or an option report identifying the most appropriate technique, but of course this only signifies that strengthening was or is being planned, but it is very possible that the scheme could have been halted before it was implemented.

Without resorting to visiting each structure in turn to try and identify if the strengthening had been implemented, it was necessary to look for signs in any recent Principal Inspection reports or accept the information provided.

Although this is a 'positive' and not a negative example, the following identifies what can happen when suitable documentation does not exist. An audit was being carried out on a masonry arch structure that the asset database identified as being sub-standard and this was also the view of the bridge manager. During the course of the audit, the auditor, only through his personal experience of masonry arch strengthening techniques, noticed from a photograph in a recent Principal Inspection report that the structure had recently been strengthened. Upon querying this with the bridge manager, it was determined that they had only just taken over responsibility for the structure within the last couple of years. It later transpired that it had been strengthened along with a number of others just prior to the re-organisation and that the relevant records had not been transferred. Throughout the course of the audits there were other examples of records going astray as a result of a change in the managing organisation.

5.4.5 Electronic record archives

Some organisations had taken the step of converting to an electronic archive and disposing of their paper records. It was commented upon by a number of engineers that since the transfer an appreciable amount of the information appeared to have been lost. Of course, it may have been that some of the 'lost' information was never scanned or perhaps had never existed, but during the course of those audits when accessing the electronic archive, it became clear that a proportion of this "lost information" had been scanned, but had been incorrectly indexed to another structure.

In most, if not all cases, the scanning and indexing was out-sourced to a specialist company and it would seem highly likely that those carrying out the scanning and indexing process would have had little, if any, understanding of the records they were working with and therefore would have been unable to identify whether a particular document was being indexed to the correct structure. It is unrealistic to expect any other bridge owners planning to undertake a similar task to ensure that the actual work is carried out by their engineers, but it is advised that particular attention be paid to ensuring that all documentation is correctly filed prior to being sent for scanning and that the electronic archive is rigorously checked before the paper records are dispensed with.

5.5 Funding for interim measures

Although an isolated case found on only one occasion, there was an example of a small number of structures being managed primarily through monitoring that were refused continued funding for the following financial year. In this instance the measures had been previously approved by the Technical Approval Authority and a formal BA79 signed by the necessary parties.

This example highlights the potential issues where the mechanism for the allocation of funds is remote from either the day-to-day bridge engineers and/or the Technical Approval Authority. In these situations, it would appear necessary to consult with those individuals who allocate funding when developing the management strategy so that they are aware that although the imposition of interim measures overall is a cost saving measure when compared to the alternatives of strengthening, replacement or closure etc.) they will have continual funding requirement.

6 DISCUSSION ON OPTIONS FOR THE DEVELOPMENT OF BA79

This section highlights and discusses the available options identified during the project for improving safety and the effectiveness of the application of BA79.

6.1 Re-issuing as a process-driven Departmental Standard

It was suggested during the course of one of the interviews that the document, after any necessary re-drafting, ought to be re-issued as a departmental standard, as opposed to the current departmental advice note. This would both increase the level of implementation and also clarify its status with regard to PFI/DBFO type schemes. It is believed that this was the intention when BA79 was originally drafted, but due to significant reservations raised by a number of organisations, it was downgraded to an advice note.

During the remaining interviews and audits, this issue was discussed. The overall view was that the majority, but not all, of the Overseeing Organisations were in favour of such a move, but the majority of Local Authority representatives were against it. The primary reason for this opposition was that it would remove the ability of engineers to apply their own judgement, and, as it was thought impossible to draft a standard to cover all eventualities, due to the potential legal liability implications, it could force engineers to adopt a specified approach even if it was thought inappropriate under the particular circumstances.

One possible approach which could be acceptable to all parties would be to change from a procedural to a process driven management system; the difference being that the standard would set out the basic steps and requirements for a safe management strategy, but would leave the actual detail of how these are achieved to each individual organisation.

It is thought likely that this approach would be best implemented through redrafting the document into a 'new style' department standard, containing both mandatory 'boxed' sections and advisory sections. The mandatory sections would set out the general process framework and the remainder would contain the advice.

If this approach were to be adopted, then there may also be merit in re-visiting BDs 21, 34, 46 and 50, in particular the way they interface with BA79. In particular, BD21 is primarily a technical document, but contains a small amount on management procedures and it is seen as the primary reference document, with BA79 as the supplementary document. There may be benefit in removing the management aspects of BD21 and where appropriate placing them within a revised BA79, resulting in one document covering management issues and one covering the technical requirements of the assessment process.

6.2 Sub-standard structure management file

As has been noted previously in this report, there were many occasions where there was insufficient or contradictory documentation to be certain about the status of a specific structure in terms of:

- its current assessment load rating,
- if sub-standard, what, if any, interim measures had been implemented,
- if being managed through monitoring, was the monitoring being carried out and recorded,
- had it been strengthened, replaced etc.

It was not always possible to clarify these aspects by talking to the bridge engineers.

Clarity in these respects would have aided this audit immeasurably, but far more importantly in the wider context would:

- provide the bridge owner with far more reliable information on which to base their management decisions and ensure the safe and effective management of their network
- guard the bridge owner against loss of information due to the loss of individual members of staff/change of managing agent
- in the case of legal action in case of collapse etc, provide a clear auditable record to demonstrate that structure was being managed to current best practice.

One option to remedy this situation is for a dedicated management file to be created for each sub-standard structure. It would be created as soon as the results of an assessment is known and be a live document following and documenting each stage of the management process until the structure is no-longer deemed sub-standard, by means of re-assessment, strengthening, replacement etc. The document would not need to include full copies of all documents appertaining to the structure, but merely the relevant sections to provide a means of recording and documenting the key technical facts, the approval of the Technical Approval Authority (or equivalent) for each stage of the management process and that any agreed measures have been implemented and are continuing to be maintained.

A significant proportion of the information required for the file is (or should be) already available. Therefore the process should not be overly bureaucratic to implement or the file too burdensome to prepare and maintain. However, by bringing all the necessary information into one file (preferably single volume and each page individually numbered) the entire process of managing a sub-standard structure would become more manageable and transparent.

6.3 Current contents of BA79

Whereas the previous parts of this chapter were concerned with improving the overall management process for sub-standard bridges through major changes, this section covers options for minor changes to the content of the current document if it is deemed appropriate to re-draft and re-issue it.

6.3.1 "Introduction"

The general view gained from the results of the questionnaire and audits was that the definitions as given in clause 1.8 of the current BA79 were clear and this view was generally upheld by the results of the audit. The only, but important, exception was what constituted a sub-standard structure.

Some organisations chose to take an holistic view and had chosen to include all structures that were structurally sub-standard in some fashion or were currently adequate but if any further deterioration in the condition were to occur then they were likely to become sub-standard. However, the most common variation was whether the references to non-carriageway sections of bridges were deemed to include sub-standard parapets and piers.

In light of the above the definition of what should constitute a 'sub-standard' structure and is suitable for management using BA79 was discussed with various bridge managers in the course of the audits and interviews. In particular it was discussed whether the scope of the document ought to be expanded to include such aspects as:

- Low headroom
- Scour
- Abnormal loads
- Pier impact
- Parapet impact

There were general differences of opinion as to the suitability of each of the above, but there were two opinions that were voiced regularly, namely:

1. Any attempt to expand the scope of the document is likely to dilute its focus thereby potentially introducing confusion and ambiguity.
2. The document should only be used to manage the risks resulting from both 'normal' and lawful usage.

These views suggest that on the whole bridge owners would prefer the scope of the document not to be expanded and that it should only consider normal vehicular loading, thereby, by implication, excluding impact to both parapets and supports. It appears that this is the intention of the definition currently given in BA79, but it would benefit from confirmation and further clarification.

The only other cause for concern was an isolated interpretation of clause 1.2. One engineer was of the opinion that he did not have to implement BA79, the reason given was that they had still not completed their Bridge Assessment and Strengthening programme and it was stated that "It is intended that this Advice Note will provide guidance beyond the current programme...". It is thought unlikely that this was the intention of the clause and instead it was intended that the management process be instigated as soon as a structure is found to be unable to support 40 tonne vehicles.

6.3.2 "Assessment"

With the exception of the out-of-date references to the forthcoming introduction of the 40 tonne vehicle onto the UK road network, the only issue raised on the subject of the assessment is the inclusion of guidance on the various levels of assessment. These issues are considered in section 6.3.7

6.3.3 "Immediate risk structures"

The results of the questionnaire indicated that a large proportion of the organisations surveyed did not have a formal process for advising of an immediate risk structure, but thought the inclusion of a recommended procedure would be beneficial.

The intention of the question posed within the questionnaire was to investigate whether procedures were in place to ensure the correct actions were implemented as a matter of urgency, such as for informing road network managers and deciding and arranging for the urgent implementation of any emergency interim measures thought necessary.

However, based upon some of the responses received, it is also possible that the question was interpreted to mean "Is guidance needed on what constitutes an "immediate risk" and therefore this is an area that interviews indicated could also warrant further guidance.

At least two organisations used methods based on a system developed by Hampshire County Council. The method involves reducing the various partial safety factors to the minimum values which would still give an acceptable short term risk level. If the structure is still unable to support 40 tonne vehicles then it is deemed an immediate risk structure. One user recognised that the method was not theoretically rigorous, but "is over 10 years old, hadn't failed them yet and is the best they've got". Whereas the use of such an approach would be unwise as a means of increasing assessment ratings, it would appear to be suitable for the use to which it was being applied.

6.3.4 "Interim measures during assessment"

BA79 requires that, unless "low risk", interim measures of some form should be implemented as soon as an assessment indicates that a structure is inadequate to carry 40 tonne vehicles. However, there was very little evidence that this approach was being adopted by the majority of bridge owners. Instead BA79 was found to be being used primarily to justify the imposition of interim measures on completion of the assessment process.

This view may be partially due to the fact that BA79 was only introduced in 1998 when the assessment programme was well advanced.

It may also be partially due to the fact that the approval system is thought to be overly bureaucratic by some and therefore it is only implemented when interim measures are likely to be in place for a significant period of time.

Therefore there would be benefit in investigating ways of making the whole system easier and less bureaucratic to implement. One approach that could be adopted is the change to a process-driven system as discussed in section 6.1.

It may also be the case that the political implications of imposing formal interim measures and then removing them if they are found to be no longer necessary following more advanced assessment are making engineers reluctant to implement such measures. To the non-informed and non-technical, this course of action can give the impression that the bridge engineer is not competent.

6.3.5 “Interim measures on completion of assessment”

The primary area of concern with this topic was the requirement that interim measures should only be in place for a maximum of two years. It is almost universally recognised that it is not possible to adhere to this requirement, especially for local authorities where funding is particularly restricted.

6.3.6 “Prioritisation for strengthening”

A large proportion of the organisations surveyed already had a system in place for the prioritisation of strengthening works, but more than 50% of the respondents to the questionnaire thought that the inclusion of additional guidance in this area would be beneficial.

During the course of the audits a number of different systems were identified. One organisation used a system based on the Hertfordshire County Council model which included the following input variables:

- Assessed weight capacity
- Anticipated type of failure
- Likelihood of assessed weight capacity being exceeded
- Location of structural inadequacy
- No HGVs encountered
- Road type

The results of the assessment provided each structure with a risk category, which was then combined with data on the road type and compared against a prioritisation listing which had been predefined by the organisation's senior management.

Another organisation had a similar system but with the following input variables:

- Traffic flow
- Assessed weight limit
- Length of diversion
- Standard of diversion
- Interim measures implemented
- Level of upgrading work required
- Risk of failure
- Consequences of failure

In addition, a number of organisations noted that it is necessary to temper the results of any prioritisation system with knowledge of the works that could be accommodated within the particular financial year.

6.3.7 “Principles and levels of assessment”

Table 6.1 demonstrates the variation in the level (ie. complexity) of the last documented assessment for all the structures audited. It is quite clear that structures on the motorway and trunk road network appear to have been subjected to more complex assessments than those on the local road network. Perhaps this is only to be expected as motorway and trunk road structures are on the whole likely to be more complex than local authority structures, warranting more complex assessments.

Level of assessment	Motorway and trunk roads	Local roads	All structures
1	31%	75%	51%
2	36%	11%	25%
3	11%	6%	8%
4	0%	0%	0%
5	0% ⁹	0%	0%
Not known	22%	7%	15%
Number in sample	236	203	439

Table 6.1 – Levels of assessment employed

However, there is also the possibility that the managers of motorway and trunk road structures have access to more funding than those managing the local authority stock and therefore are able to undertake more costly assessments.

During the course of the interviews, the benefits of including information on the levels of assessment were discussed, in most commonly used levels, namely 1, 2 & 3. Views on this topic were mixed. Some were of the opinion that increasing awareness of the options available through the inclusion of this information had raised the quality of assessment work and consequently the assessment ratings achieved. However, others thought that the information gave the impression that all assessments ought to start at level 1 and work their way to 2, then 3 etc. until all options were exhausted or the structure was found to be no longer sub-standard, which is not always the case. This is thought to be an area where additional guidance on the use and order of the various levels could be beneficial.

Less positive was the overall view on the provision of information on Level 4 and 5 assessments. As can be seen from Table 6.1 (as clarified by footnote 9), there was only one structure within the audit sample that was assessed to either level 4 or 5, and the results of that one assessment did not appear to come to any firm conclusions. The benefit of these particular sections was discussed with a number of the interviewees and their views ranged from the neutral to the negative.

Those with neutral views on the topic were of the opinion that they are so rarely used it makes no difference whether the guidance is retained or removed

Those with negative views on the subject were generally of the opinion that in the absence of detailed advice on how to carry out such advanced assessments (ie. an advice note) the guidance ought to be removed. Of particular concern was clause B5.3 which some thought

⁹ There was one structure audited that was assessed to Level 5, but due to rounding of the statistics it is presented in table 8.1 as 0%.

could be interpreted as allowing engineers to lower partial safety factors without any real justification or understanding of the consequences.

On a similar topic, the subject of the yield line methods was raised during a number of the audits. A number of structures had been analysed using yield line methods, particularly on the motorway and trunk road network. On a number of occasions there was uncertainty amongst bridge engineers as to the validity of the results obtained. In one case, yield line analyses were carried out on a number of structures, using full partial safety factors and the bridges in question were found adequate for 40 tonne vehicles. However, the bridge engineers in question deemed this insufficient evidence and implemented interim measures, using the results of the yield line analyses essentially as part of a risk analysis to help inform the extent of the interim measures required. This is also an area where further guidance could be of benefit.

6.3.8 “Monitoring of sub-standard structures”

One area identified for improvement during the course of the study was guidance on what frequency of monitoring is appropriate for a specific set of circumstances. It has already been commented upon that a significant percentage of sub-standard structures are only monitored every one or two years, which does not adhere to the spirit of the existing advice note. As risk is related to the probability of an event occurring and time, the frequency of inspection is a key parameter and therefore this is an area that warrants further consideration.

One of the organisations visited had developed such a system that could provide a basis for this additional guidance. They developed a risk assessment process using a similar approach to the strengthening prioritisation systems referred to earlier. The input information required was:

- Load assessment rating
- Condition factor
- Other interim measures
- Road classification
- Predicted failure mechanism
- Obstacle being crossed

Based on the results of this assessment, a monitoring interval was identified which varied between immediate action to a maximum monitoring interval 6 months. The procedure permitted the monitoring frequency to be adjusted by the engineer, either from the offset, based on engineering judgement, or as an action following from the results of an inspection.

6.3.9 “Interim measures appraisal proformas”

The current Interim measures appraisal proformas included within BA79 were found to be used only in by two of the Overseeing Organisations, and are considered by the majority of participating organisations to be too bureaucratic for their needs. It would therefore seem reasonable to examine ways for simplifying the form, to incorporate the needs of more bridge owners. One particular aspect noted was the number of signatures required for approval, which was deemed excessive by the majority of bridge owners.

7 CONCLUSIONS

The results of the project indicate that there was significant variability in the level of implementation of BA79 throughout the bridge owners audited and there were an appreciable number of sub-standard structures for which there was no evidence of them being managed either in strict compliance with or in the spirit of the advice note. A number of these structures were being managed by organisations where its use would appear to be mandatory.

If these results are a true reflection of the entire UK it can be deduced that an appreciable percentage of bridge owners/managers do not implement BA79, neither in strict compliance nor in the spirit of the advice note. Therefore, in the absence of contradictory information, it is only possible to conclude that where they have sub-standard structures they are not always managing the risk of collapse in a safe and auditable manner.

In addition, where sub-standard structures are being managed to BA79, the quality of documentation of the management process and the base data on which the management strategy is based are variable.

Therefore it appears that the greatest level of risk in the management of sub-standard structures stems from this lack of consistency and limited application of the document, and the quality of the records on which the management processes are based, rather than the technical quality of its application.

Where bridge owners/managers have chosen to implement BA79, in the majority they have adopted the spirit of the document but not the detail. This would appear to suggest that BA79 is over complex and would benefit from both simplification and clarification providing a general framework in which to work, but allowing bridge owners to develop the detail of their systems depending on their specific circumstances. A number of organisations have gone some way towards developing their own system, as well as producing useful forms and risk management tools.

8 RECOMMENDATIONS

From the evidence collected it appears that the greatest level of risk concerning the management of sub-standard structures stems from the consistency and extent of application of BA79, and the quality of the records rather than the technical quality of application.

It is recommended therefore that BA79 would benefit from significant revision, rather than minor piecemeal changes to individual sections of text. The primary recommendations stemming from this study are:

- that BA79 should be re-drafted into a process-driven departmental standard (BD) as opposed to the current procedurally-driven advice note (BA), thereby encouraging wider and more consistent implementation (ref. section 6.1).
- that as an aid to the management process, each sub-standard structure should be provided with a dedicated management file to provide a single source of information documenting all management actions from the day it is first identified as being provisionally sub-standard through to when it is no longer deemed sub-standard, by means of more advanced assessment, strengthening or replacement etc. (ref. Section 6.2)

In addition to these major changes, during the re-drafting process the opportunity should be taken to address minor issues and provide additional guidance on the following points:

- the definition of a sub-standard structure (ref. 6.3.1)
- methods of identifying “immediate risk structures”, and the development of appropriate systems to ensure each occurrence is managed in a safe and efficient manner (ref 6.3.3)
- methods of developing risk assessment tools for the prioritisation of strengthening work (ref 6.3.6) and monitoring frequency (ref 6.3.8)
- the development of appropriate assessment strategies for specific bridge groups to improve bridge ratings in a cost efficient manner (ref 6.3.7).

9 REFERENCES

- | | |
|------|---|
| BA79 | The Management of Sub-standard Highway Structures |
| BD21 | The Assessment of Highway Structures |
| BD34 | Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 1 – Older Short Span Bridges and Retaining Structures |
| BD46 | Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 2 – Modern Short Span Bridges |
| BD48 | The Assessment and Strengthening of Highway Bridge Supports |
| BD50 | Technical Requirements for Assessment and Strengthening Programme for Highway Structures: Stage 3 – Long Span Bridges |
| BD52 | The Design of Highway Bridge Parapets |



APPENDIX A – SUMMARY OF QUESTIONNAIRE RETURNS

Questionnaire Responses

