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The Stage 2 Structural Assessment of Sub-Standard Road Structures

AM-STR-06057
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AM Asset Management & Maintenance

Standards

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This document has been authorised by the Director of Professional Services, Transport Infrastructure Ireland. For any further guidance on the TII Publications system, please contact the following:

Contact: Standards and Research Section, Transport Infrastructure Ireland
Postal Address: Parkgate Business Centre, Parkgate Street, Dublin 8, D08 DK10
Telephone: +353 1 646 3600
Email: infoPUBS@tii.ie

TII Publications

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1. Introduction

1.1 General

The purpose of this Standard is to outline the requirements for the Stage 2 Structural Assessment of road structures that have either been assessed to be sub-standard according to the requirements of AM-STR-06026 'The Assessment of Road Bridges and Structures' or are deemed to be sub-standard by other methods.

The procedures detailed in this Standard are mandatory. This Standard shall be used in conjunction with other documents contained in TII Publications. Any deviation from these procedures requires the approval of a Departure from Standards.

If this Standard is to be used for the assessment of regional, local or unclassified road structures, the Lead Structural Assessment Engineer should agree with the relevant road authority the extent to which the document is appropriate in the particular situation.

If the Stage 2 Structural Assessment of any bridge or structure shows it to be inadequate, then the actions described in AM-STR-06039, shall be considered and included in the recommendations section of the Structural Assessment Report (refer to Chapter 7 and Appendix C of this document).

If it is considered that further significant deterioration of the structure may compromise the serviceability of the bridge, the condition of the bridge shall be monitored by Special Inspections at intervals not exceeding the intervals as agreed with TII in consultation with the Bridge Management Section of Transport Infrastructure Ireland (TII).

If, in the course of an assessment, a structure is found to be so inadequate such that there is an immediate risk to public safety, the procedure described in AM-STR-06039 regarding action for "Immediate Risk Structures" shall be followed.

It will be necessary to submit at least 2 reports as part of all Stage 2 Structural Assessments as follows:

a) At the outset a Technical Acceptance Report (TAR) shall be prepared and submitted prior to any analysis being undertaken in accordance with the provisions of Chapter 2 of this Standard.

b) A Stage 2 Structural Assessment Report (SAR) shall be prepared and submitted following the completion of all inspections, investigations and analysis in accordance with Chapter 7 of this Standard.

A summary of the management processes required as part of this Standard has been provided in the form of a flowchart and is included as Appendix A.

1.2 Scope

This Standard covers the assessment of bridges constructed of steel, concrete, wrought iron and cast iron, as well as the assessment of brick and stone masonry arches. It does not cover timber structures or stone slab bridge decks.

This Standard is intended to be used in conjunction with AM-STR-06026, which contains advice on the assessment of the load carrying capacity of bridges and other structures.

The scope of DN-STR-03001 includes the assessment of all road structures affected by national road schemes and the procedures described in that standard should generally be applied to Stage 2 Structural Assessments as described in Chapter 2 of this document.

This Standard contains requirements and guidelines for methods of structure idealisation and load distribution for different types of bridge construction as well as advice on the inspection and testing requirements for the completion of the Stage 2 Structural Assessment of road structures.

1.3 Assessment Stages

Assessment of an existing structure should be carried out in stages of increasing complexity, with the objective of efficiently determining its adequacy. Early stages may contain conservative means of determining load effects. Provided that a structure is shown to be adequate at these stages, then no further analysis is required. However, if a structure is found to be inadequate at an early stage then assessment work should continue, and later stages should seek to remove any conservatism in the assessment calculations.

The assessment stages considered by TII are as set out below. Stage 1 Structural Assessments shall be carried out in Accordance with AM-STR-06056 'The Stage 1 Structural Assessment of Road Structures'. The appropriate level of assessment for a structure shall be determined in conjunction with TII in consultation with the Bridge Management Section of TII.

If at any stage of the assessment process, it is deemed that there will be no obvious benefit in continuing, assessments may be stopped subject to agreement with TII. All such deliberations and decisions should be carefully recorded and a close out report/file issued to TII detailing the works completed and the reasons for the suspension of the assessment. The format of the close out report shall be determined on a case by case basis with TII but, as a minimum, shall include all of the relevant information, as described in Chapter 7 of this Standard, up to the point of the suspension.

1.4 Stage 1 Assessment

Stage 1 is the simplest level of assessment, giving a conservative estimate of load capacity. Structures assessed to Stage 1 shall follow the procedure outlined in AM-STR-06056.

1.5 Stage 2 Assessment

A Stage 2 Structural Assessment involves the use of more refined analysis and better structural idealisation. This more refined analysis should follow the recommendations described in Chapter 5 whenever it is considered that these may result in higher assessed capacities.

As part of the Stage 2 Structural Assessment process the Structural Assessment Engineer shall be required to review the findings of all available calculations (both design and assessment), comment on the level of conservatism upon which any assumptions have been founded and correlate the findings of the most recent Stage 1 Structural Assessment with the findings of the Inspection for Assessment.

The Stage 2 Structural Assessment shall make use of both material testing to determine characteristic strength or yield stress, and Worst Credible Strength or Worst Credible Yield Stress when it is considered that the use of such factors would result in a structure achieving the required load rating. This is described in more detail in Chapters 3 and 4. Reference should also be made to AM-STR-06031 and AM-STR-06010 for further guidance on the application of Worst Credible Strength partial factors for concrete structures and to Annex H of AM-STR-06035 for procedures in allowing the use of Worst Credible Yield Stress factors for steel.

1.6 Stage 3 Assessment

If a Stage 2 Structural Assessment as specified in this document does not demonstrate the adequacy of a structure then a Stage 3 Structural Assessment as defined in documents AM-STR-06039 and AM-STR-06057 should be considered.

This more advanced assessment involves the use of specialist techniques such as Bridge Specific Assessment Live Loading (BSALL), reliability-based methods of assessment and load testing according to AM-STR-6014.

For long span bridges (loaded lengths greater than 50m), where the 40 Tonne Assessment Live Loading fails by a small margin, the use of BSALL may be beneficial.

Guidance on the use of reliability-based methods of assessment is provided in Appendix C of AM-STR-06039 and may be used with the agreement of TII and/or the Bridge Management Section of Transport Infrastructure Ireland. Such methods require specialist knowledge and expertise.

Load tests should be complementary to the analytical process and are not to be considered as a replacement for the usual assessment procedures. Guidance for load testing of bridges is given in Chapter 3 of AM-STR-06026 with further advice contained in AM-STR-06014.

Further guidance on the appropriate application of these techniques in relation to Stage 3 Structural Assessments is provided in Chapter 6.

2. Stage 2 "Technical Acceptance Report" Requirements

2.1 Scope

The scope of DN-STR-03001 includes the assessment of all road structures affected by national road schemes. The procedures described in that standard should generally be applied to the undertaking of Stage 2 Structural Assessments.

In addition, the specific Technical Acceptance requirements outlined below are mandatory for all Stage 2 Structural Assessments unless otherwise agreed with TII.

2.2 Definitions

The terms described in Chapter 1 of DN-STR-03001 shall also apply to this Standard.

Particular terms used in this Standard are defined as follows:

Lead Structural Assessment Engineer: He/she shall be a Chartered Engineer with a recognised University degree to Level 8 or equivalent with a minimum of 10 years post graduate experience in the design or assessment of bridge structures. He/she must have experience as a Team Leader in both conservative and refined assessment of relevant masonry, concrete and steel bridge structures using contemporary methods and software packages.

Structural Assessment Engineer: He/she shall be an engineer with a recognised University degree to Level 8 or equivalent with a minimum of 7 years post graduate experience in the design or assessment of bridge structures. He/she must have experience in assessment of relevant masonry, concrete and steel bridge structures using contemporary methods and software packages.

2.3 Technical Approval and Certificates

It is essential that there is dialogue between the Assessment Team and the Bridge Management Section of TII when the scope and complexities of the Stage 2 Structural Assessment develop, particularly where this requires increasing input of both subjective and engineering judgement.

2.4 Instructions for Structures

Technical Acceptance Reports for Stage 2 Structural Assessments are required for all categories of structures. Any structure that is subject to a Stage 2 Structural Assessment shall be deemed to be, as a minimum, a Category 2 Structure.

Appendix B illustrates the layout of the Technical Acceptance Report that is considered to be appropriate for a Stage 2 Structural Assessment. The application form (STA-2) located in DN-STR-03001 should be bound into the report inside the front cover.

The accompanying model for a Technical Acceptance Report for a Stage 2 Structural Assessment should not be regarded as prescriptive nor should its contents be regarded as exhaustive. However, Lead Structural Assessment Engineers are expected to have considered all of the headings in the model and shall demonstrate such consideration by developing the heading or stating that it is not relevant. New headings should be introduced at the end of each section, where appropriate.

Text should be concise and to the point.

Appendices shall be used to include where available:

a) Archive information and technical papers relating to the bridge.
b) Photographs.
c) Drawings.
d) Extracts from factual site investigation data.
e) Structure geotechnical summary sheets/extracts from geotechnical interpretative reports.
f) Third party reports.
g) Lists of standards to be used.

The appendices should include references to other reports, studies and working papers, which were used to develop the Stage 2 Structural Assessment to the Technical Acceptance stage.

2.5 Reports

The reports should be in A4 format and portrait page layout. Drawings should be A3, folded to A4 size and bound into the document.

The executive summaries should be not more than one A4 page. The body of the report between 1.0 and 8.0 should be contained in approximately 6 A4 pages. The reports should be in 12-point font.

Unless otherwise agreed Technical Acceptance Reports shall be submitted to TII prior to commencing any materials testing or assessment calculations.

2.6 Application for Technical Acceptance

The purpose of the Technical Acceptance Report is to enable TII to be satisfied as to:

a) Compliance with TII approvals procedures.
b) The likelihood that further structural assessment could be sufficient to identify the required reserves of strength not previously considered as part of the Stage 1 Structural Assessment.
c) The adequacy of the information available to undertake the assessment.
d) The robustness of the review made of all Stage 1 assumptions and boundary conditions.
e) The adequacy of proposals for determining material properties and other investigations.
f) The loading and other assessment criteria proposed.
g) The suitability of the assessment method(s) proposed for use in the assessment.
h) The application of selected documents and Standards, and the suitability of any methods or criteria outside existing Codes or Standards proposed for adoption in a particular structure.
i) The need for consultation with interested authorities and potential sources of additional information.

Technical Acceptance shall not be provided by TII until all foreseeable aspects have been addressed and any differences resolved to the satisfaction of TII.

Application for Technical Acceptance for the Stage 2 Structural Assessment of structures shall include:

a) The form ‘Application for Technical Acceptance’ (STA-2 completed).

b) One copy of the Technical Acceptance Report.

The Structures Inspector will issue the Technical Acceptance for the Assessment of Structures (STA-5A) certificate when satisfied with the application.

Together with the STA-5A certificate the Structures Inspector will issue a blank Structural Assessment and Check (STA-6A) certificate which must be completed and returned when the Stage 2 Structural Assessment has been completed and checked.

2.7 Checking and Certification

The requirements for checking Stage 2 Structural Assessment calculations shall generally be as set out in DN-STR-03001 Chapter 3 in so far as they relate to assessment rather than design. However, the minimum Category of check for any Stage 2 Structural Assessment shall be Category 2.

The requirements for certification of Stage 2 Structural Assessments shall be as set out in DN-STR-03001 Chapter 3 in so far as they relate to assessment rather than design.

2.8 Role of Transport Infrastructure Ireland

The role of TII and their nominated Structures Inspector shall be consistent with Chapter 1 of DN-STR-03001 when applied to Assessment rather than design activities.

3. Inspection for Assessment

3.1 General

A Stage 2 Structural Assessment of a structure to determine its load carrying capacity involves not only analysis and calculations but also the detailed inspection of the structure and testing of materials.

In general, a Stage 2 Structural Assessment will follow on from inadequacies identified during a Stage 1 Assessment. Therefore, an inspection to verify the form of construction, the dimensions of the structure and the nature and condition of the structural components should be available to the Structural Assessment Engineer. Where this is the case, the inspection for the Stage 2 Assessment should:

a) Confirm and document the findings of the inspection for the Stage 1 Assessment.

b) Provide a very detailed inspection of the structural component or element deemed to have inadequate capacity.

The very detailed inspection referred to above shall include but not be limited to:

a) Crack mapping.

b) Size, spacing and orientation of cracks.

c) Visual assessment of material quality.

d) Extent and severity of corrosion.

e) Evidence of accidental damage.

f) Evidence of previous repairs.

g) Any other signs of overstress in the element.

Sketches and photographs of the findings of the very detailed inspection shall be included in the Structural Assessment Report described in Chapter 7.

3.2 Inspection

Where a Stage 1 Assessment has not been undertaken, the Inspection for Assessment shall include all of the inspection and testing requirements of Chapter 2 of AM-STR-06026 and AM-STR-06056 in addition to the requirements of the Stage 2 Structural Assessment outlined below.

The inspection should cover not only the condition of individual components but also the condition of the structure as an entity and especially noting any signs of distress and their cause.

For a Stage 2 Structural Assessment the inspection shall be undertaken by a Structural Assessment Engineer in accordance with the requirements of Chapter 2 of AM-STR-06026, unless superseded by a particular requirement of this Standard.

Prior to commencing an Inspection for Assessment as part of a Stage 2 Structural Assessment, the Technical Acceptance Report as described in Chapter 2 and the consultations described in Chapter 4 shall be completed, submitted to and approved by the relevant road authority. This is especially important for Stage 2 Structural Assessments and should specifically target the information that should be obtained during the Inspection for Assessment.

Where dead load contributes more than 60% of the overall load effect, the geometry and density of materials shall be accurately determined by reference to validated as-built data or testing as appropriate. When as-built drawings are relied upon to provide this information their accuracy shall be confirmed through on site validation.

Where there is doubt in relation to any of the parameters necessary to accurately determine the strength of members and elements this shall be highlighted to TII and its significance in terms of the overall assessed capacity determined. If it is deemed to be a highly significant factor, trial pits or testing should be undertaken as described below.

Where bridge substructures and foundations are identified as the primary reason for undertaking a Stage 2 Structural Assessment, the inspection shall be undertaken in accordance with Chapter 2 of AM-STR-06026. In addition, all of the information to allow a quantitative assessment of the substructure should be gathered either by the provision of as-built data or through the digging of trial holes and testing as necessary.

3.3 Sampling and Testing

The results of the testing required as part of the Stage 1 Structural Assessment shall be utilised as part of the Stage 2 Structural Assessment process. Where testing has not been undertaken as part of the Stage 1 Structural Assessment process, and it is considered that materials testing may lead to an increase in material strengths, then as a minimum the testing required in AM-STR-06056 shall be undertaken.

A technical proposal and the particular objectives for the site investigation should be defined in the Technical Acceptance Report, following the desk study and review of current site conditions. The Lead Structural Assessment Engineer should prepare an associated schedule of sampling and testing to determine the material properties of the structure in the vicinity of the critical sections under investigation. Where appropriate, all material sampling, laboratory and site testing should be carried out by specialist testing firms or laboratories approved by the Irish National Accreditation Board (INAB) for the type of laboratory testing required, or by equivalent accreditation bodies of member states within the EU.

Testing organisations shall be required to provide a track record of experience in using the intended equipment with an operator experienced in interpreting the results in relation to the structure of the bridge construction type involved.

3.4 Concrete

The number of cores to be extracted from an individual concrete structure or member within a structure shall be such that the equation provided in Annex A of AM-STR-06010 provides the maximum benefit when considering the use of worst credible strengths.

The condition of the concrete and the effect of extracting cores within the particular element of the structure identified to have inadequate structural capacity during the Stage 1 Structural Assessment should be considered prior to undertaking partially destructive tests.

Where non-destructive testing coupled with the extraction of cores is proposed within the Technical Acceptance Report, a minimum of 3 No 100mm diameter cores shall be extracted. All samples shall be extracted and tested in accordance with IS EN 12504: 2009 and IS EN 13791: 2007.

3.5 Steel/Wrought Iron

The methods given in Annex H of Appendix A of AM-STR-06035 for deriving the assessment yield stress of steel depend on the extent of knowledge of the origin and properties of the steel used in a structure.

The use of these methods offer advantages for recent structures when there are several relevant Mill Test Certificates showing a mean strength substantially greater than the specified minimum. This information should be sought as described in Chapter 4.

Owing to the uncertainties involved in assessing population statistics from small numbers of samples, it would be necessary to undertake many tests on steel structures to obtain a significant benefit in relation to the assessment capacity. This will seldom be practical. Therefore, sampling of steel should only be considered in cases where the mean yield stress is relatively high and/or many relevant test results are available. Where testing is required the samples should be taken and tested in accordance with IS EN 10002: 2001.

The yield stress of wrought iron varies over a wide range, typically from 180 to 340N/mm^2. The Structural Assessment Engineer must determine if testing is likely to benefit the assessment calculations.

Where it is deemed likely that the strength of the material could significantly increase the assessed capacity of a wrought iron structure or member a minimum of twenty test results should be taken on the particular element or member that has been deemed to be deficient. However, the condition of the wrought iron and the effect of such extensive partially destructive tests must be carefully considered.

3.6 Masonry

Most masonry arch bridges do not have reliable records of construction or early repair details. It may, therefore, be difficult to determine the physical dimensions of the main structural elements, or the presence of features such as haunching (backing) at supports, saddles over the barrel, internal spandrel walls and ribs. Many unsuspected examples of these features have only been discovered during demolition or repair. Inadequate knowledge of the layout and dimensions of the structural elements may lead to an overly conservative assessment of the structure's load carrying capacity. Therefore, as part of a Stage 2 Structural Assessment of a masonry arch bridge the following information must be obtained:

a) The actual geometry of the arch – survey from beneath.

b) The arch barrel construction – thickness, integrity and material properties.

c) The backfill – fill depth and material properties.

d) The presence of hidden features – ribs, chambers etc.

The following methods should be considered to obtain the required information:

a) Cores of no greater diameter than 75mm should be retrieved to determine arch barrel thickness, from the arch barrel close to the crown and quarter point and a third core if necessary to help verify the backing depth. At least 2 cores should be retrieved from each arch and it is expected that no more than 3 cores will be required for most arches. It should be noted that cores may not always provide a true indication of the actual arch barrel thickness as the presence of backing or the backfilling of the arch using surplus material during construction may make it difficult to distinguish between arch barrel and backing. Core voids shall be reinstated using appropriate materials and finished with a mortared section of stone from the core.

b) Consideration should be given to the digging of trial holes over the arch structure where feasible to determine the arch barrel thickness. This may not be possible in all circumstances (e.g. where there is a significant depth of fill over the structure; where there are a significant number of services present; where significant traffic management is required; or where the local environment does not lend itself to the digging of trial holes). It may be necessary to supplement the information gained from the trial holes with the retrieval of cores from the intrados of the arch barrel.

c) Non-destructive testing and investigation where it has a proven track record in providing the information required.

The compressive strength of the masonry should only be determined for critical cases, such as where crushing of the masonry at the hinge points has been identified during the Inspection for Assessment. In the absence of any other reliable information, 3 core samples should be taken in order to determine the compressive strength of the voussoir units. All testing shall be carried out in accordance with IS EN 1052.

3.7 Cast Iron

Cast iron members are to be assessed on a permissible stress basis only, in accordance with Chapters 3 and 4 of AM-STR-06026. Due to the variability of the material it is not envisaged that material sampling would be undertaken on cast iron sections as part of any Stage 2 Structural Assessment.

4. Assessment for Resistance

The objective of this standard is to produce a realistic assessment of the strength of a structure by taking account of as-constructed material properties as well as worst credible partial material safety factors where it is considered that these could provide an increased allowable safe working resistance for a given structure.

A critical part of this approach to maximise the assessed capacity of a structure is to obtain as much information as possible about the existing structure. The Lead Structural Assessment Engineer shall review all of the information relating to the structure and shall prepare a scoping document outlining the extent of information required to increase the levels of certainty associated with the structure.

This shall be achieved through the use of the Technical Approvals process described in Chapter 2. However, in addition to the preparation of the Technical Approvals submission, enquiries shall be made of all other possible sources of information about the structure including; the original Designers of the structure; the Contractor responsible for the construction of the structure; fabricators of proprietary materials (precast prestressed beams, steel sections, etc.); historical societies and reference libraries (e.g. Engineers Ireland, Local Authority, Institution of Civil Engineers, etc.). The results of these enquiries shall be included in the Stage 2 Structural Assessment Report described in Chapter 7.

4.1 Worst Credible Strengths

As part of a Stage 2 Structural Assessment the Structural Assessment Engineer shall allow for the actual material strengths of the structures and structural elements being assessed. Worst credible strength has been defined as the worst value of that strength which the engineer, based on his experience and knowledge of the material, realistically believes could be obtained in the structure or element under consideration. Since this value eliminates some of the uncertainties associated with the use of characteristic strengths, reductions can be made in the material partial safety factor.

Worst credible strengths shall be derived from tests carried out on a structure. A combination of partially destructive testing at non-critical locations and non-destructive testing at critical locations of an element should be undertaken followed by interpolation or extrapolation, as necessary, to arrive at worst credible strengths in these locations.

Further advice in relation to the application of worst credible factors for concrete is provided in Annex A of AM-STR-06010. Advice in relation to the application of worst credible factors to steel is provided in Annex H to Appendix A of AM-STR-06035.

4.2 Limit State

In general, structures should be assessed by the application of limit state principles. The limit state to be adopted for this Standard shall be the ultimate limit state, using appropriate partial factors. However, for masonry arch bridges and cast iron bridges alternative assessment methods may be adopted in accordance with the recommendations of AM-STR-06026.

The serviceability limit state shall only be considered when the need for this has been agreed with the relevant road authority.

4.3 Loading

The loading to be applied for a Stage 2 Structural Assessment shall be in accordance with the requirements of Chapter 5 of AM-STR-06026.

Reduction factors for uniformly distributed load (UDL) and knife-edge load (KEL) shall be in accordance with Chapter 5 of AM-STR-06026 unless otherwise agreed with TII.

For a Stage 2 Structural Assessment it is important to establish what component of the loading contributes most to the overall load effect. Therefore, load combinations shall be included for dead load, superimposed dead load and live load in isolation as well as in combination.

4.4 Properties of Materials

A Stage 2 Structural Assessment is generally required as a result of an initial assessment that indicated inadequacies or where there was doubt about a particular material. Therefore, the material properties of the element or member displaying the inadequacy should be verified by testing. The extent of testing for each material type considered in this standard is described in Chapter 3.

4.5 Strengths of Members

The strengths of members shall be determined in accordance with the following standards:

Concrete	AM-STR-06031	The Assessment of Concrete Highway Bridges and Structures
Steel	AM-STR-06035	The Assessment of Steel Highway Bridges and Structures
Composite	AM-STR-06037	The Assessment of Composite Highway Bridges and Structures
Masonry Arch	AM-STR-06002	The Assessment of Highway Bridges and Structures

For Stage 2 Structural Assessments, the Structural Assessment Engineer shall take account of all known reserves of strength available to him within the codes in order to demonstrate that the structure is capable of sustaining the applied loads. This includes the investigation of potentially hidden reserves of strength such as compressive membrane action and parapet edge stiffening. In addition, the detailing of some structures may allow for the justification of increased capacities when examined from first principles that may allow for the use of partially anchored bars, inclined bars and the limiting of peak stresses. Further guidance on methods of analysis for structures is provided in Chapter 5 of this standard.

5. Analysis of Structure

5.1 General

In general, the first step in a Stage 2 Structural Assessment is the modelling of the structure taking into account the three-dimensional effects of load distribution and the contribution of the different structural elements using linear elastic models. This is achieved by the use of grillage or shell finite element models or equivalent analytic models.

If the section capacity is exceeded using this analysis, a further load redistribution using non-linear material and geometric analysis should be developed. There are several commercial software packages and numerical methods available (finite element, finite differences, and structure type specific methods).

This analysis requires specialist knowledge in the use of the particular software package, the assumptions and limitations of its use, and the theoretical background on which it is based. The Lead Structural Assessment Engineer shall be responsible for determining the type of analysis to be performed. The assumptions, limitations and other relevant observations of the structural analysis chosen shall be clearly specified in the appropriate sections of the Assessment Report together with details of the software package utilised.

The results of non-linear or plastic analysis shall be checked against a linear elastic analysis using the same model, loads and boundary conditions.

Mean values of the material properties should be considered when non-linear analysis is known to be sensitive to certain parameters. Either a sensitivity analysis or an upper- and lower-bound analysis are recommended for those parameters that are known to have a significant influence in the global factor of safety of the structure.

The use of cracked section properties in concrete structures produces a redistribution of forces in the structure leading to more realistic results when considered. The use of cracked section properties does not necessarily lead to a plastic behaviour of the structure unless the reinforcement reaches its yield stress, and in this case, the analysis can be considered as non-linear elastic.

In Ultimate Limit State analysis, tension stiffening and the contribution of the concrete tensile capacity shall be ignored.

The use of plastic hinges and, in general, the use of an elastic-plastic analysis requires a certain level of ductility of the section where the plastic hinge is located. The final rotations and displacements obtained in the global model shall be checked against the ductility capacity of the section to develop the required displacement or rotation.

Detailing in reinforced and prestressed concrete sections and local instability effects in steel sections shall be analysed in conjunction with the global analysis.

For guidance in this area, refer to AM-STR-06035, Appendix A, Chapter 7 for steel structures and AM-STR-06031, Appendix A, Chapter 4 for concrete structures.

When non-linear geometrical analysis is considered, the final deflections of the overall structure for the ultimate load, and the local rotations of the critical elements should be checked as part of the assessment.

Appropriate geometric imperfections should be taken into account under this type of analysis.

Fully non-linear step-by-step methods are recommended over simplified methods such as p-δ analysis.

5.2 Global Analysis Methods

5.2.1 Buried Structures and Retaining Walls

Either two-dimensional (plane frames) or three-dimensional (grillages or shell) finite element models can be considered. When two-dimensional models are used, an appropriate, non-over-conservative, transversal dispersion of the loads should be taken into account.

Soil-structure interaction should be taken into account either by the use of non-linear springs or the appropriate type of finite element to take into account the behaviour of the soil as a non-elastic continuum (shell in 2D models or brick in 3D models).

5.2.2 Stone and Masonry Arches

If a two-dimensional (plane) beam model is used, then a full non-linear analysis, including geometry, material properties and soil-structure interaction, should be taken into account. A realistic, non-over-conservative spread of the wheel loading and any other relevant loads or transverse distribution effect should be taken into account in the model.

Several commercial packages are available which could be used in a Stage 2 Structural Assessment provided the requirements indicated in this section are taken into account.

Alternatively, general three-dimensional finite element analysis taking into account soil-structure interaction and elastic-plastic material properties can be considered. The Lead Structural Assessment Engineer should provide adequate justification of the modelling assumptions and method of analysis considered in this type of analysis.

5.2.3 Concrete Frames

Reinforced concrete frames should be analysed using a grillage model where the soil-structure interaction is considered and the transverse distribution of loads is taken into account.

If non-linear or plastic analysis is carried out, an idealized tri-linear moment-curvature (or moment-stiffness) diagram is recommended. The moment-curvature diagram is dependent on the axial force present in the section and the effects of the axial load should be taken into account.

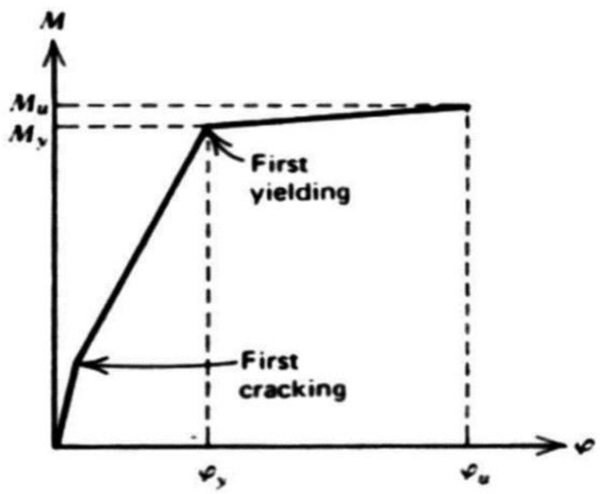


Figure 1: Moment curvature diagram

Moment curvature diagrams can be obtained by the use of section analysis software or alternatively the stress-strain relationships of the materials can be directly considered.

5.2.4 Concrete Slabs

Concrete slabs should be analysed using general shell Finite Element Method (FEM) models and taking into account the dispersion of loads as appropriate and orthotropic element properties including the contribution of the reinforcement. If less complex FEM elements such as plates are considered its use must be justified.

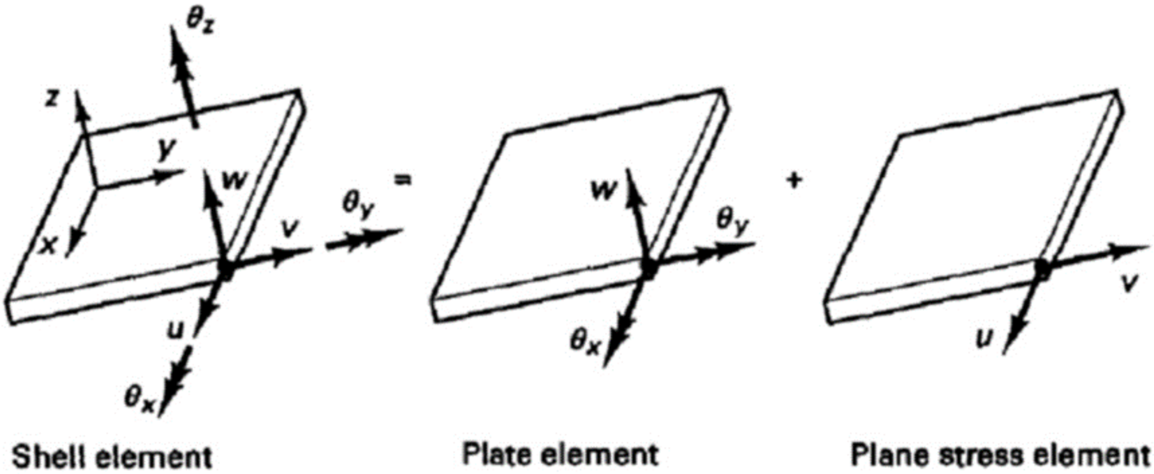


Figure 2: General shell as a combination of plate and membrane (plane stress) elements.

Alternatively to FEM analysis, analytical methods such as a general yield line method may be considered if properly justified. Yield line methods provide an upper bound solution and, when used, the rotational capacity of the critical sections should be proven.

5.2.5 Continuous Beam and Slab

Three dimensional models (grillages or shell elements) should be used to obtain the load effects in Beam and Slab structures. If two-dimensional models (plane frame model) are used, the effects of transversal load redistribution need to be properly justified to avoid over conservative assumptions. Material non-linearity as described in section 5.1 should be considered when appropriate.

In Ultimate Limit State analysis the effects of stress redistribution at section level due to creep and shrinkage can be ignored.

5.2.6 Steel-Concrete Composite Deck

The principles indicated in Chapter 5 are applicable to steel-concrete composite bridges.

5.2.7 Steel Structures (Trusses, Steel Orthotropic Boxes etc.)

Appropriate three-dimensional models taking into account the distribution of loads should be used.

Non-linear geometric and mechanical analysis using static push over or equivalent solver methods allowing the development of plastic hinges should be considered. Initial geometric imperfections must be taken into account.

A bilinear elastic-plastic stress strain constitutive equation for the steel is recommended.

5.2.8 Cable Supported Structures

Appropriate modelling of the cable sag and stiffening of anchor elements should be used when the effects of cable forces are considered in cable supported structures.

5.3 Local Analysis Methods

In addition to global models to obtain a realistic behaviour of the structure, the following recommendations cover the local analysis of particular elements that should be considered where appropriate.

The list of elements identified for local analysis in this section is not exhaustive, depending on the type of structure under assessment, additional local models not covered in this section might need to be considered. The Lead Structural Assessment Engineer shall clearly identify any local analysis required.

5.3.1 Horizontal Shear in Beam and Slab Bridges

When the elastic analysis of the horizontal shear in beam and slab bridges fails, a fully plastic redistribution can be considered to analyse the horizontal shear between beam and slabs.

This effect can be modelled using independent frame elements for the beam and the slab, linked by non-linear springs using an elastic-plastic force-displacement diagram, which reflects the maximum capacity of the reinforcement or shear connectors at the interface between the beam and the slab. The influence of this redistribution of horizontal shear should be taken into account in the assessment of bending capacity of the composite section.

5.3.2 Membrane Action

The local effects of wheel loads on reinforced concrete slabs can be assessed using compressive membrane action. If this analysis is carried out, the recommendations of AM-STR-06040 'Use of Compressive Membrane Action in Bridge Decks' shall be taken into account.

5.3.3 Section Analysis of Concrete Members under Shear

The Modified Compression Field Theory has proven to be a successful tool in predicting the ultimate capacity of reinforced and unreinforced beam elements working under shear loading and, in addition, provides an accurate prediction on the development of cracking patterns in non-linear analysis. The use of available software to obtain the ultimate capacity of sections under combined shear and bending is recommended in those cases where conventional analysis fails to satisfy the required capacity.

5.3.4 Discontinuity Zones in Concrete

The use of general Strut-and-Tie Models (STM) to evaluate the capacity of discontinuity zones (areas where there is an abrupt change in geometry or load introduction) is recommended. In these areas, the assumption that plane sections will remain plane (see AM-STR-06031 Chapter 5) is not applicable.

Load paths should be chosen in accordance with the reinforcement provided in the section. Compression struts should take advantage of the maximum compressive strength of concrete taking into account confinement effects where appropriate. Where statically indeterminate STM models are proposed the plastic truss method is recommended.

Smeared cracked tension stiffening models in concrete are not recommended unless specific experimental tests are used as a benchmark to provide certainty in the concrete constitutive equation considered.

5.3.5 Local Buckling and Ultimate Capacity of Slender Stiffened or Unstiffened Steel Sections

The use of three-dimensional shell models to obtain the ultimate capacity of slender steel sections is recommended. The analysis should include material and geometrical non-linear behaviour. Special attention to the specific boundary conditions, load introduction and geometric imperfections should be considered.

6. Stage 3 Structural Assessment

6.1 General

In many cases, bridges which seem to be carrying normal traffic satisfactorily without any undue signs of distress have "failed" assessment calculation. Understandably, Structural Assessment Engineers have been reluctant to condemn such bridges on the basis of calculations alone and, consequently, there has been growing interest in alternative methods as possible means for increasing the assessed capacity.

For the purposes of this Standard, Stage 3 Structural Assessments shall be considered under four headings:

a) Advanced Structural Analysis;

b) Bridge Specific Assessment Live Loading (BSALL);

c) Reliability-based Methods of Assessment and;

d) Load Testing.

6.2 Advanced Structural Analysis

Structural analysis techniques not considered under Chapter 5 of this Standard may be considered to be categorised as a Stage 3 Structural Assessment.

6.3 Bridge Specific Assessment Live Loading

For short span bridges (loaded length less than 50m), it is generally not considered cost effective to develop Bridge Specific Assessment Live Loadings as AM-STR-06026 already takes account of varying traffic flows and surface irregularities. However, there may be particular situations, for example, when heavy vehicles cannot reach the structure because of width restrictions or tight bends, where it may be appropriate to accept a lower Assessment Live Loading for short span bridges on minor roads, when agreed with TII.

For long span bridges, where the 40 Tonne Assessment Live Load fails by a small margin, the use of BSALL should be explored with TII.

6.4 Reliability-Based Methods of Assessment

Reliability-based methods of assessment determine whether the probability of failure of a structure is acceptably low within the framework of the limit state principals. Reliability-based methods may, therefore, be of benefit in cases where, for a specific structure or element of a structure, the code-specified partial factors lead to a particularly conservative probability of failure, compared with that required of similar structures or elements.

Reliability-based assessments require specialist knowledge and expertise and are particularly useful in situations where the disruption costs of replacement or repairs are significant in terms of the overall management of the structure.

If reliability-based assessments are proposed as part of a Stage 3 Structural Assessment, TII should be consulted in respect of the methods and criteria to be used. In establishing the criteria to be used in an assessment, it may be appropriate to take the consequences of failure into account.

For the purpose of reliability differentiation, consequence classes (CC) have been established by considering the consequences of failure or malfunction of the structure. The proposed CC are presented below.

The three consequence classes can be associated with reliability classes (RC). The reliability classes are defined by the reliability index, β, calculated using the equation, $\beta = -\Phi(Pf)$, where Φ is the distribution function of the standardised normal distribution and Pf is the probability of the limit state under consideration being exceeded.

Table 1: Definition of consequence classes

Consequence Class	Description	Examples of buildings and civil engineering works
CC3	**High** consequence for loss of human life, or economic, social *or* environmental consequences **very great**	Grandstands, public buildings where consequences of failure are high (e.g. a concert hall)
CC2	**Medium** consequence for loss of human life, economic, social or environmental consequences **considerable**	Residential and office buildings, public buildings where consequences of failure are medium (e.g. an office building)
CC1	**Low** consequences for loss of human life, and economic, social or environmental consequences **small or negligible**	Agricultural buildings where people do not normally enter (e.g. storage buildings, greenhouses)

6.5 Load Testing

Load testing for Stage 3 Structural Assessments should be undertaken in accordance with AM-STR-06014.

Load testing is primarily aimed at seeking out the hidden reserves of strength within a structure. Therefore, the bridges most likely to benefit from this approach are those which contain features where such reserves may be found, and for which load testing is a practical proposition. This includes:

a) Short span stocky structures.

b) Older structures where material properties are highly variable.

c) Structures that are assessed to be inadequate in flexure.

d) Structures that have been treated as simply supported but may exhibit a degree of continuity.

Load testing as part of a Stage 3 Structural Assessment should consist of supplementary load tests only as described in AM-STR-06014. These tests are those where vehicle, axle or patch loads, or combinations thereof, are placed on a bridge to determine individual aspects of its load resistance capacity so that assumptions made in the theoretical assessment can be made more pertinent to the individual structure. Such tests are carried out when the Lead Structural Assessment Engineer suspects that the structure may be stronger than indicated by a purely theoretical assessment. There is no single procedure for supplementary load tests and each case has to be treated individually.

Because there is a risk of collapse during a proving load test, or of damage to essential elements of the structure, proving load tests shall only be undertaken following approval with TII. The use of such tests should be limited to bridges which, on the basis of their assessments, would have been closed to traffic and would otherwise require to be demolished.

7. Stage 2 “Structural Assessment Report” Requirements

Individual Structural Assessment Reports (SARs) shall be produced for each structure assessed in accordance with this Standard. Structural Assessment Reports shall only be issued following approval of the TAR described in Chapter 2 and completion of the Stage 2 Structural Assessment process as described in the flowchart provided in Appendix A.

All Structural Assessment Reports shall be prepared against a similar framework and should include the following chapter headings:

- Introduction
- Form STA-6A
- Executive Summary
- Structure Description
- Stage 1 Structural Assessment Summary
- Stage 2 Structural Assessment Inspection Summary
- Stage 2 Assessment Methodology
- Assessment Commentary
- Stage 2 Assessment Results
- Recommendations

Appendix C of this Standard contains a sample cover page and a brief description of each Chapter to be prepared as part of the Stage 2 Structural Assessment Report.

The Stage 1 Structural Assessment Summary should include the following information as a minimum:

a) Date of assessment.

b) Assessing organisation.

c) Extent to which the structure failed the assessment.

d) Mode of failure.

e) Original assumptions made and a commentary on their significance in terms of the assessed capacity of the structure.

f) Details of any strengthening works undertaken as a result of the assessment.

g) Description of any changes to the load effects or assessment resistance since the original assessment.

h) Results of any monitoring or inspections undertaken.

i) The assessed capacity.

The Stage 2 Structural Assessment Inspection Summary shall include text to identify and justify the condition factor used in the assessment calculations as well as a detailed description of the testing undertaken to allow the use of worst credible strength partial factors, if applicable.

The description of the Stage 2 Assessment Methodology shall match with the description provided in the Technical Acceptance Report issued to TII.

The Assessment Commentary shall highlight all of the assumptions made during the Stage 2 Structural Assessment and provide commentary on the significance of these assumptions in relation to the overall capacity of the structure or element.

In addition to giving the overall assessed capacity of the structure, data shall be presented about all elements, especially those that were critical to the Stage 1 Assessment failure, including:

a) Critical element identity.

b) Value of load effects.

S_D^* (Assessment load effects due to dead and superimposed dead loads)

S_A^* (Assessment load effects)

S_{HA}^* (Assessment load effect due to the associated Type HA loading)

S_{HB45}^* (Unfactored load effect due to 45 units of Type HB loading)

c) Assessment Resistance (R_A^*).

d) Mode of failure and

e) Structural Adequacy Factor R_A^*/S_A^*.

Where the results of a Stage 2 Structural Assessment fail to demonstrate the adequacy of the structure, recommendations shall be provided in the Stage 2 Structural Assessment Report in accordance with the guidance given in AM-STR-06039. These recommendations must include unequivocal advice in relation to proposals on the actions required to either:

- progress to a Stage 3 Structural Assessment
- initiate the design of strengthening works, or
- initiate a programme of continued monitoring.

The following Appendices shall be provided with each Stage 2 Structural Assessment Report:

a) Archive Information relating to the structure.

b) Results of literature search described in Chapter 4.

c) General Arrangement drawings.

d) Structural Condition drawings.

e) Copy of materials testing report.

f) Structure idealisation model and model inputs.

g) Calculations.

h) Photographs.

The Structural Assessment Report cover page shall comply with Appendix C of this Standard and include an elevation photograph of the bridge with revision status and date to be printed at the foot of the page.

All reports shall be spiral bound and two copies of each report shall be forwarded to the Regional Bridge Manager. A PDF version of the report shall also be forwarded to the Regional Bridge Manager.

The Structural Assessment Engineer shall forward on a CD to the Regional Bridge Manager all photos which have been taken of the structure during site visits. All photos shall be date stamped.

8. References

8.1 TII Publications (Standards) References

DN-STR-03001 - Technical Acceptance of Road Structures on Motorways and Other National Roads

AM-STR-06002 - The Assessment of Road Bridges and Structures

AM-STR-06010 - The Assessment of Concrete Road Bridges and Structures

AM-STR-06014 - Load Testing for Bridge Assessment

AM-STR-06026 - The Assessment of Road Bridges and Structures

AM-STR-06030 - Loading for highway bridges

AM-STR-06031 - The Assessment of Concrete Road Bridges and Structures

AM-STR-06035 - The Assessment of Steel Highway Bridges and Structures

AM-STR-06039 - The Management of Sub-standard Road Structures

8.2 Other Miscellaneous References

Safety of Historical Stone Arch Bridges (Dirk Proske, Pieter van Gelder. Springer Verlag 2009)

FIB Bulletin 45. Practitioners guide to finite element modelling of reinforced concrete structures. (CEB-FIB Task group 4.4. June 2008)

Finite Element Design of Concrete Structures. Second Edition (G.A. Rombach. Thomas Telford 2011)

Limit Analysis and Concrete Plasticity. Third Edition (M.P Nielsen, L.C. Hoang, Taylor Francis, 2011)

Nonlinear mechanics of Reinforced Concrete (K. Maekawa, A. Pimanmas, H. Okamura. Spon Press 2003)

Steel Structures. Design Using FEM (Rolf Kindman, Mattias Krauss. Ernst & Sohn 2011)

Appraisal of Existing Structures. Third Edition 2010. Published by The Institution of Structural Engineers. ISBN 978-1-906335-04-5

Bridge Assessment and Testing – Update (2009-2010). TRL, Transport Research Laboratory 2010, Ref CT128.3

Guidance on the assessment of concrete bridges. Technical Guide 9, 2007, Concrete Bridge Development Group

Masonry arch bridges: condition appraisal and remedial treatment. CIRIA Publication C656, 2006

Enhancing the capacity of concrete bridges. Technical Guide 10, 2008, Concrete Bridge Development Group

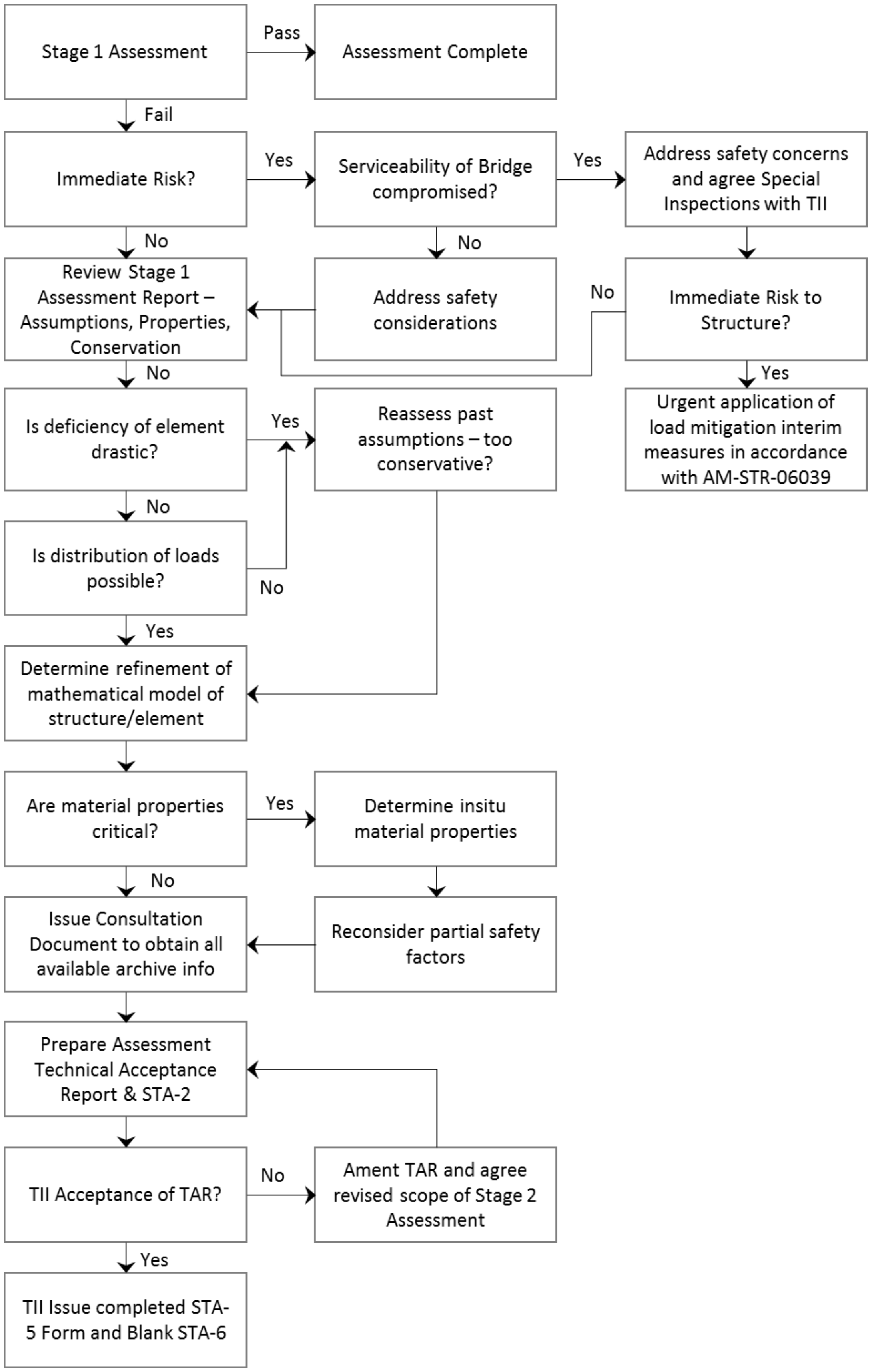
Iron and steel bridges - condition appraisal and remedial treatment. CIRIA Publication C664, 2008

Procedures required for assessing highway structures. WG 2 and 3 report: methods used in European states to assess the condition of highway structures. TRL, Transport Research Laboratory 2004, Report COST 345 WG 2 and 3

Appendix A:

Stage 2 Assessment Process

Document Information



Appendix B:

Stage 2 Structural Assessment Technical Acceptance Report

Document Information

TECHNICAL ACCEPTANCE REPORT FOR {NAME AND NATURE OF STRUCTURE}

Application for Technical Acceptance

B.1. Include STA-2

Document Information

TII Reference number

Revision* number and date. Nature of revision and page reference.

Author name and initials.

Checker's name and initials.

Executive Summary (1 A4 page)

B.2. Structure

Name:

EIRSPAN Structure ID:

Location (co-ordinates):

Local Authority:

Primary function:

Check Category:

Assessment Loading:

B.3. Passages

Primary

a) Number
b) Name
c) AADT

Other (multiple if necessary – river, rail, path, etc.)

a) Number:
b) Name:
c) AADT or passage type:

B.4. Summary of Stage 1 Structural Assessment Results

Extent of deficiency in assessed capacity.

B.5. Assumptions

Include a detailed commentary on the significance of all assumptions and boundary conditions made in Stage 1 Assessment.

B.6. Testing Proposed

Summary of material tests and investigations required to refine assessment calculations.

B.7. Summary of Proposed Structure Idealisation Model

Include a brief description of the software to be used and the main properties of the structural model.

1.0 Introduction

a) Instructions or brief given to the authors, including dates.

b) Background information covering the origins for the need for the structural assessment.

c) Previous reports and their recommendations.

d) Available archive information and results of consultations.

e) As required.

2.0 Site and Function

a) Site location.

Described generally with reference to existing towns and roads. Location map at 1:50,000 or other agreed scale.

b) Function of the structure and obstacles crossed.

c) Vertical and horizontal alignments.

d) Cross sectional dimensions.

e) Geotechnical summary.

f) As required.

3.0 Structure

a) General description of structure.

Brief summary of number and length of spans, skew, articulation and materials.

b) Span arrangements.

c) Substructure.

d) Foundation type.

e) Superstructure.

f) Articulation arrangements, joints and bearings.

Statement of whether the structure is fully integral or not and justification of the articulation arrangement. Description of bearings and movement joint, i.e. saw cut, buried joint, asphaltic plug joint, mechanical joint, etc.

g) Parapet.

Brief Details of parapet.

h) Materials.

Details of types of materials used in the structure including grades of steel and concrete for elements of the structure. Details of the concrete mix (i.e. GGBS).

i) As required.

4.0 Structural Assessment Criteria

a) Review of the results of the Stage 1 Structural Assessment.

b) Detailed commentary on the significance of all of the assumptions made during the Stage 1 assessment and proposals for validation of these assumptions.

c) Review of testing undertaken as part of Stage 1 Assessment.

d) Testing proposed to refine structural assessment as part of Stage 2 analysis.

e) Assessment live loading.

f) Abnormal loading.

g) Additional loading requirements.

h) As required.

5.0 Structural Analysis

a) Summary of analysis methodology undertaken as part of Stage 1 Structural Assessment.

b) Methods of analysis proposed for Stage 2 analysis including justification as to how this may lead to an increase in the assessed capacity for the superstructure, substructure and foundations.

c) Description of the model proposed for the analysis and software to be used.

d) As required.

6.0 Ground Conditions

a) Available ground investigation data.

b) Evidence of vertical or lateral ground movements or settlements due to embankment loading, mineral extraction, flowing water, etc.

Measures proposed to deal with these effects as far as they apply to the structure.

c) As required.

7.0 Checking

a) Category of structure.

b) As required.

8.0 Drawings and Documents

a) List of all documents accompanying the submission.

Appendices to Accompany the Technical Acceptance Report

a) Archive information and technical papers relating to the bridge.

b) Photographs.

c) Drawings.

d) Extracts from factual site investigation data.

e) Structure geotechnical summary sheets/extracts from geotechnical interpretative reports.

f) Third party reports.

g) Lists of standards to be used.

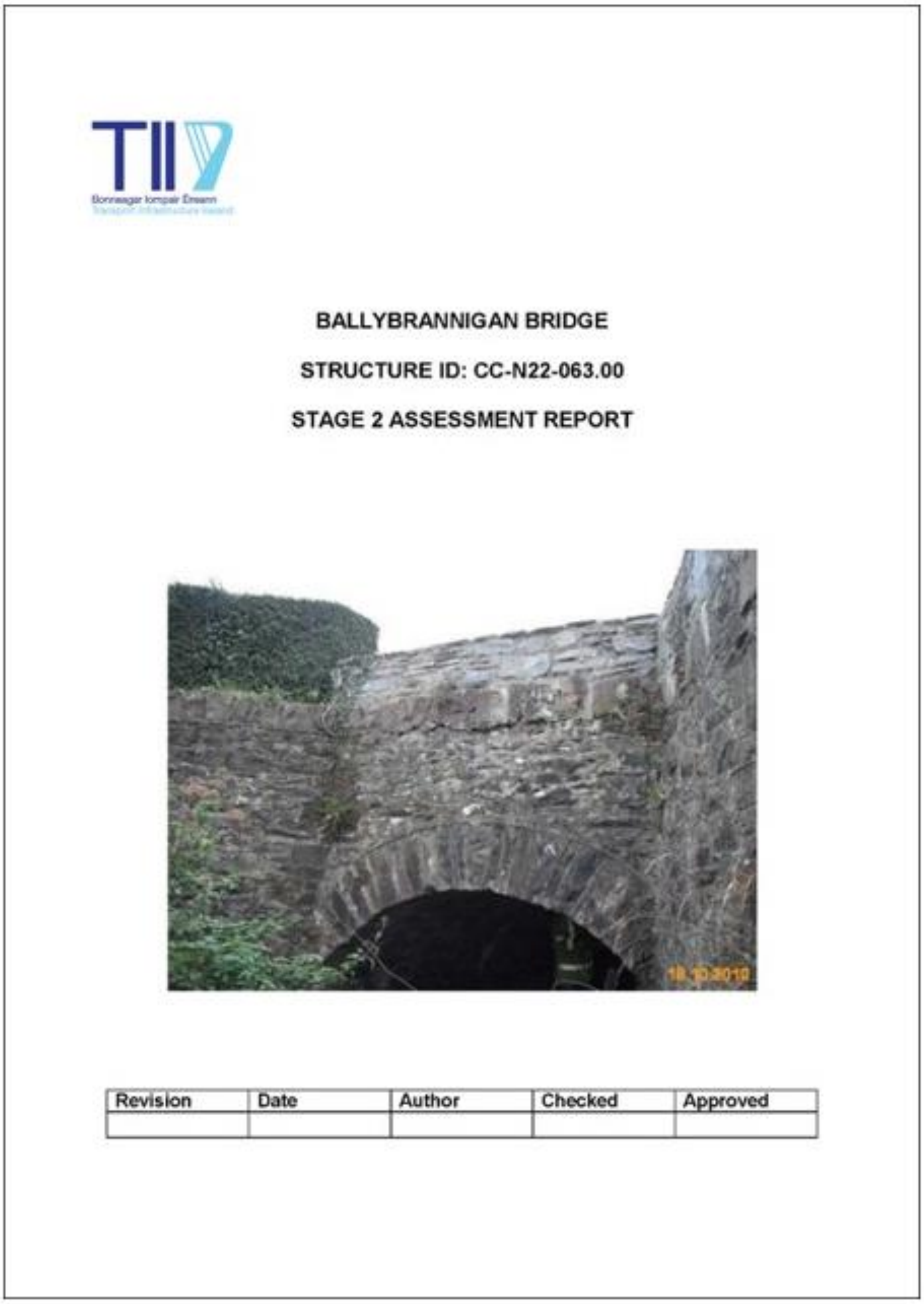
Appendix C:

Stage 2 Structural Assessment Report

Structural Assessment Report for {Name and Nature of Structure}

Individual Stage 2 Structural Assessment Reports shall be produced for each structure assessed in accordance with Chapter 7 of this Standard.

The Structural Assessment Report cover page shall comply with this Appendix and include an elevation photograph of the bridge with revision status and date to be printed at the foot of the page.



BALLYBRANNIGAN BRIDGE

STRUCTURE ID: CC-N22-063.00

STAGE 2 ASSESSMENT REPORT

Revision	Date	Author	Checked	Approved

The format of all Stage 2 Structural Assessment Reports shall be as follows:

Chapter 1 – Introduction

Chapter 2 – Form STA-6A

Chapter 3 – Executive Summary

Chapter 4 – Structure Description

Chapter 5 – Stage 1 Structural Assessment Summary

Chapter 6 – Stage 2 Structural Assessment Inspection Summary

Chapter 7 – Assessment Method

Chapter 8 – Assessment Commentary

Chapter 9 – Assessment Results

Chapter 10 – Recommendations

Chapter 1 – Introduction

a) Instructions or brief given to the authors, including dates.

b) Background information covering the origins for the need for the structural assessment.

c) Previous reports and their recommendations.

d) Available archive information and results of consultations.

e) As required.

Chapter 2 – Form STA-6 A

a) Include signed copy of STA-5A Form.

b) Include original, signed and dated STA-6A Form.

Chapter 3 – Executive Summary

a) To include a brief description of; the structure; the reason for undertaking a Stage 2 Assessment; the existing available information; the inspection and materials testing undertaken; the method of analysis; the results of the Stage 2 Structural Assessment; and any recommendations.

Chapter 4 – Structure Description

a) As per section 3.0 of Technical Acceptance Report.

b) Confirmation of any changes to properties.

Chapter 5 – Stage 1 Structural Assessment Summary

a) Date of assessment.

b) Assessing organisation.

c) Review of testing undertaken as part of Stage 1 Assessment.

d) Review of the results of the Stage 1 Structural Assessment.

e) Extent to which the structure failed the assessment.

f) Detailed commentary on the significance of all of the original assumptions made during the Stage 1 assessment in terms of the assessed capacity of the structure.

g) Mode of failure.

h) Details of any strengthening works undertaken as a result of the assessment.

i) Description of any changes to the load effects or assessment resistance since the original assessment.

j) Results of any monitoring or inspections undertaken.

k) The assessed capacity.

Chapter 6 – Stage 2 Structural Assessment Inspection Summary

a) Detailed description of the findings of the visual inspection.

b) Identification and justification of the condition factor used in the assessment calculations for each structural element.

c) Detailed description of the testing undertaken.

d) Results of all testing undertaken.

e) Summary of partial safety partial factors used in assessment.

f) Summary of all material properties used in the assessment.

Chapter 7 – Assessment Method

a) Summary of analysis methodology undertaken as part of Stage 1 Structural Assessment.

b) Detailed description of method of analysis undertaken for Stage 2 analysis including justification as to how this has led to an increase in the assessed capacity for the superstructure, substructure and foundations.

c) Description of the model and software used for the analysis.

d) Assessment live loading.

e) Abnormal loading.

f) Additional loading requirements.

Chapter 8 – Assessment Commentary

a) Highlight all of the assumptions made during the Stage 2 Structural Assessment.

b) Provide commentary on the significance of these assumptions in relation to the overall capacity of the structure or element.

Chapter 9 – Assessment Results

a) In addition to giving the overall assessed capacity of the structure, data shall be presented about all elements and the mode of failure, especially those that were critical to the Assessment failure, in the following format.

Element	Location in Structure	Load Effect	RA*	SD*	SHA*	SHB45*	RA*/SA*

Where

R_A* = Assessment Resistance (flexure, shear etc.)

S_D* = Assessment load effects due to dead and superimposed dead loads

S_{HA}* = Assessment load effect due to the associated Type HA loading

S_{HB}* = Load effect due to HB loading

S_A* = Assessment load effects

R_A*/S_A* = Structural Assessment Factor

Chapter 10 – Recommendations

a) Provide recommendations for the future management of the structure.

b) Where the results of a Stage 2 Structural Assessment fail to demonstrate the adequacy of the structure, recommendations shall be provided in accordance with the guidance given in AM-STR-06039.

c) These recommendations must include unequivocal advice in relation to proposals on the actions required.

d) Benefits of progress to a Stage 3 Structural Assessment.

e) Whether to initiate the design of strengthening works.

f) Any risks associated with continued monitoring.

The following Appendices shall be provided with each Stage 2 Structural Assessment Report:

a) Archive Information about the structure.

b) Results of literature search described in clause 4.3.

c) General Arrangement drawing showing testing locations.

d) Structural Condition drawing.

e) Copy of materials testing report.

f) Structure idealisation model and model inputs.

g) Calculations.

h) Photograph.

Appendix D:

Forms

Introduction

The forms STA-5A and STA-6A have a similar appearance. They include the following information:-

a) Header with the RA name and the form name.

b) Administrative information and dates of events such as submissions and acceptances.

c) History of Conditions, Revisions, etc.

d) Acceptance text and signatures.

Examples of typical forms are shown overleaf.

TRANSPORT INFRASTRUCTURE IRELAND

________________________ **COUNTY COUNCIL**

Technical Acceptance for Structures

STA-5

Scheme ________________________

TII Reference ____________ Designers Reference ________

Structure Name ________________________

Category

____

Technical Acceptance Report

Submitted ____________ Technical Acceptance Report Reference ____________ TA

Accepted ____________ Valid Unitil ____________

Technical Acceptance

Conditions / Amendments / Addenda

No	Date	Details

This acceptance is subject to the amendments and conditions shown above

Signed ________________________

Name ________________________

Postion ____________ **Structures, Transport Infrastructure Ireland**

Date ____________

________________________ ____________TA/1 Page 1

TRANSPORT INFRASTRUCTURE IRELAND

______________________ **COUNTY COUNCIL**

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Design and Check Certificate for Structures **STA-6 Page 1 of 2**

Scheme ______________________

Category

TII Reference ______________ Designers Reference ______

Structure Name ______________________

Technical Acceptance Report

Submitted ______________ Technical Acceptance Report Reference ______________ TA

Accepted ______________ Valid Unitil ______________

Design/Check Certificate

Submitted ______________ Certificate Reference ______________ DC

Accepted ______________ Valid Unitil ______________

Design & Check

Conditions / Amendments / Addenda

No	Date	Details

______________________ ______________DC/1 Page 1 of 2

TRANSPORT INFRASTRUCTURE IRELAND

________________________________ **COUNTY COUNCIL**

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Design and Check Certificate for Structures

STA-6 Page 2 of 2

1.0	Undertaking
1.1	We certify that reasonable professional skill and care has been used in the preparation of the design of this structure and that:-
1.1.1	It has been designed in accordance with the Technical Acceptance Report referenced above and the conditions and amendments listed above;
1.1.2	It has been checked for compliance with the relevant Standards in 1.1.1;
1.1.3	The design has been accurately translated into contract drawings, specifications and bar schedules. The unique numbers of these drawings and schedules are listed in the enclosed Annex 1.

Signed ____

Name ____

Position Team Leader - Design Office or Firm

Signed ____

Name ____

Position Principal Officer or Director - Design Office or Firm

Date ____________________

Signed ____

Name ____

Position Team Leader - Design Check

Signed ____

Name ____

Position Principal Officer or Director - Design Check Office or Firm

Date ____________________

2.0 Acceptance of Certificate

Transport Infrastructure Ireland accepts this certificate

Signed ____

Name ____

Position Structures, Transport Infrastructure Ireland

Date ____________________

____

________________DC/1 Page 2 of 2

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Ionad Ghnó Gheata na Páirce,
Stráid Gheata na Páirce,
Baile Átha Cliath 8, D08 DK10, Éire

www.tii.ie

+353 (01) 646 3600

Parkgate Business Centre,
Parkgate Street,
Dublin 8, D08 DK10, Ireland

info@tii.ie

+353 (01) 646 3601