Eurocode transition

Eurocodes evolution: assessment of existing structures

Mungo Stacy and Jon Shave explain the background and content of the new Eurocode for assessment of existing structures, examining aspects such as scope, principles and interventions.

Introduction

Two previous articles in *The Structural Engineer* on the second-generation Eurocodes have explained the objectives of the Eurocodes evolution programme[1], and the UK's implementation plans[2] with transition to second-generation Eurocodes in March 2028. This article reviews the new Eurocode content for assessment of existing structures. This is timely given the publication in March 2026 of the new BS EN 1990-2[3] covering assessment of existing structures.

Background

The UK has considerable and long experience of assessment of existing structures. The Institution of Structural Engineers guide on *Appraisal of existing structures* was first published in 1980 and is now in its third edition[4]. Bridge assessments have been driven by changes in highway traffic and railway interoperability regulations, leading to widespread assessment programmes such as Operation Bridgeguard from the 1960s onwards[5] and formalisation of bridge assessment requirements in client standards such as CS 454[6]. The acknowledgement of the climate emergency has increased interest in 'build less' approaches that maximise reuse of existing structures[7] **(Figure 1)**.

The mandate for the Eurocodes evolution programme included in its scope the development of new harmonised European technical rules for existing structures. This initiative was motivated by the increased volume across Europe of construction activities in assessing and retrofitting existing structures. It recognised the different demands of assessment compared with design and the evolution of national approaches to assessment in many countries. The objective of this work was to bring together the different national approaches to form a broadly accepted, coherent and harmonised set of rules for existing structures, complementing those for the design of new structures.

The second-generation Eurocode work proceeded in three phases. A Science and Policy Report[8] from the European Commission's Joint Research Centre (JRC) had already been produced in 2015, serving as a review of the policy framework, summarising the different national approaches and making proposals for standards content. The second phase was to convert the JRC report to a European Committee for Standardization (CEN) technical specification for optional application by countries; this was released by the British Standards Institution (BSI) as PD CEN/TS 17440 in 2020[9] with an accompanying UK National Annex. The third phase was to convert the CEN technical standard (TS) into a full normative CEN standard, which has become BS EN 1990-2[3]. UK experts were active in drafting and commenting on the documents during all three of these phases.

FIGURE 1: Refurbishment of existing structure can extend its use but may involve changes to load paths

Differences between assessment and design

Structural assessment is a different activity to structural design, despite apparent similarities between the structural calculations that are produced. A standard for assessment therefore needs to reflect these differences, which include: the level of knowledge available about the structure; approaches for determining resistance of elements and the structure, also taking into account possible deterioration; and consequences of an adverse result.

In new design, the structure is yet to be realised. Uncertainties in material properties, actions and modelling are represented using statistical distributions of assumed parameters, generally simplified for design purposes to characteristic values and partial factors. In assessment, the structure exists and so aspects such as materials and geometry are 'knowable'. However, there may be effort and cost involved in obtaining this knowledge, e.g. through

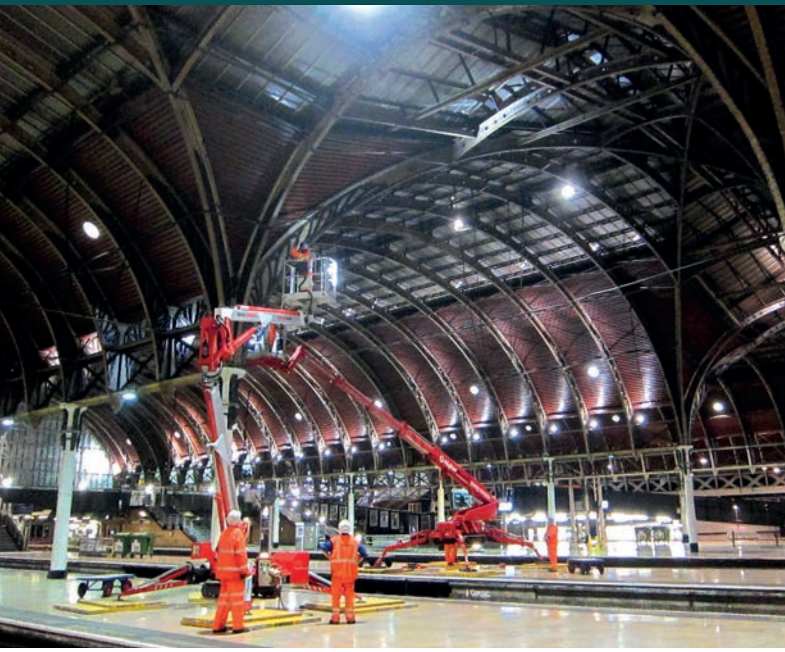

FIGURE 2: Gathering knowledge of structural condition for station canopy structure

FIGURE 3: Access arrangement for examination of bridge

review of record drawings or site examination **(Figures 2 and 3)**. It may not be possible to verify information for hidden details (e.g. quantity of reinforcement within a beam or column) without intrusive investigation. Material tests, e.g. on concrete cores, only provide a sample of the material used. Additionally, deterioration of the structure and modifications over its lifetime need to be considered.

When considering the resistance of an element or structure, starting from the 'blank sheet' of new design, it is expected that sections are sized to provide sufficient design resistance. In simple terms, this can be achieved with a tweak of the figures in a spreadsheet. For assessment, there may need to be means of dealing with historic detailing, products or materials that do not comply with current requirements, or means of improving precision of results based on the as-constructed details. This difference is illustrated by the use of Wood–Armer equations for design of reinforced concrete slabs, compared with Denton–Burgoyne equations[10] for assessment, to take account of actual rather than optimised reinforcement.

The result of a compliant new design is expected to be a 'pass'. For an assessment of an existing structure, an adverse result from the assessment can have significant consequences, potentially involving restrictions on the use of the structure, strengthening or replacement. Therefore, the assessment process is often undertaken iteratively. Where possible, lower-effort preliminary work can be used to demonstrate satisfactory performance. However, if initial results are unsatisfactory, further work can be undertaken to improve the result. For example, the term 'provisionally substandard' is used when describing intermediate results in bridge assessments[11] rather than a simple binary pass/fail.

Second-generation Eurocodes for assessment

The Eurocodes comprise a series of interrelated parts. The basis of design, EN 1990, has been split into two parts. EN 1990-1 now covers basis of design, while the new EN 1990-2 provides a companion basis of assessment. This article principally deals with EN 1990-2.

Some of the material Eurocodes include content for use in assessment. In particular, the second-generation EN 1992-1-1:2023 for concrete provides informative annexes with supplementary guidance on resistances for assessment of existing concrete structures, including those with deterioration, non-standard details or plain reinforcing bars. However, other materials provide few or no provisions for assessment, so while there is now a framework for doing assessments in the Eurocodes, there are still gaps in the detailed rules on how to carry out the resistance calculations. Therefore, use may still be needed of some of the existing well-established assessment documents from outside the Eurocodes to determine structural resistance.

As with the first-generation, the second-generation Eurocodes must be used in conjunction with their National Annexes. The National Annex for EN 1990-2 is currently being drafted, and this article is based on an understanding of the likely UK decisions for Nationally Determined Parameters (NDPs). The Eurocodes provide default choices to be used in the absence of national choice. For assessment, the default choices in Eurocode often err towards invoking the respective design requirements, although it is expected that the UK National Annex will generally include openings to allow for relevant authority or specific project choices that are more appropriate for assessment.

The drafting of the basis of assessment, EN 1990-2, followed a number of principles. The same section numbering system was used as in EN 1990-1, allowing a direct read-across between the provisions for assessment and those for design. In cases when the same provisions apply (e.g. application of the partial factor method), the content was incorporated by cross-reference rather than by duplication. Clarity was provided on which provisions apply for assessment and which apply for design.

Scope of basis of assessment

Clause 1 of EN 1990-2 sets out the scope of basis of assessment. The document provides rules for assessment of all types of existing structure, including buildings, bridges and geotechnical structures. It does not include material-specific rules, e.g. for resistance, which are expected to be covered in the material parts of the Eurocode (e.g. EN 1993 for steel). It does not include procedures for when to initiate an assessment, nor does it describe how assessment results should be used to manage the asset.

It does not cover seismic assessment, which is handled in EN 1998-3.

General rules

Clauses 2 and 3 of EN 1990-2 cover normative references and terms, definitions and symbols. Clause 4 describes general rules. Under Basic Requirements (4.1), there is an NDP which allows further clarification of the definition of an existing structure. There are some circumstances when application of EN 1990-2 could give more favourable results than application of EN 1990-1. It is expected that EN 1990-2 is only applied once a structure has been in service for some time, and it should not be used to justify non-compliances of structures that 'exist' during construction. Due to the different legal and contractual frameworks that operate across Europe, further clarification of this aspect was left to national choice.

Basic Requirements (4.1) sets out the objective of assessment, to verify that the structure fulfils the specified requirements during the remaining service life. It notes that basic requirements for an existing structure can be different from the basic requirements applicable to a new structure. The 'specified requirements' are, in turn, defined by the assessment scope and objectives in Section 5.

Principles of assessment

Clause 5 of EN 1990-2 covers principles of assessment. This key section introduces requirements that handle the differences between assessment and design identified above.

The iterative nature of assessment is covered under Assessment Process (5.1.1), which identifies that assessment may be carried out following a stepwise process with increasing levels of detail and accuracy. The informative Annex I.3 contains further guidance, including a flowchart indicating preliminary and detailed stages of assessment. If at any time the structure appears to be in a situation where the level of risk requires immediate intervention, measures to mitigate the risk should be identified.

Assessment Scope and Objectives (5.1.2) requires the scope and objectives to be specified and documented, including aspects such as extent of structure to be assessed, requirements to be fulfilled, actions to be considered, limit states to be assessed, etc. This activity corresponds to establishment of a brief for the engineer to work to. The scope and objectives should be determined based on the stage of assessment and the level of detail and effort required.

Assessment Approach (5.1.3) requires the approach to be specified and documented, including method of assessment, approach to handling deterioration, basic variables, analysis methodology, verification methods, etc. This corresponds, for example, to the content of an Approval in Principle for Assessment for bridge assessment.

Assessment Method (5.1.4) provides a framework of options for how the assessment will be undertaken. Most options are expressed as permissions, with national choices which can restrict usage of certain methods. It is expected that the UK National Annex will defer most of these decisions to relevant authorities or project-specific choices. In cases when there is a client with technical expertise, it is expected that the relevant authority will define conditions for use of the methods, e.g. for bridge owners who require consistency of assessment results across their portfolio of assets. In cases when the client has less technical expertise, it is expected that relevant parties (i.e. the engineer) will make an appropriate decision for the specific project; this will require that the assessment engineer has appropriate competence.

The partial factor method is given as the default assessment method. The framework includes the potential use of qualitative methods; specific criteria are given in Clause 10, including absence of significant distress or deterioration, satisfactory prior performance for a sufficiently long period of time, understanding of possible failure modes together with an acceptably low level of risk. Risk-informed and reliability-based methods are also included in the framework, providing the possibility of using approaches such as those described in the recent IStructE guide, *Appraising factors of safety in existing engineered structures*[12], and Hendy *et al*.[13].

Basic variables and updating

Clause 6 of EN 1990-2 gives requirements for selecting values for the basic variables: actions, materials, geometry. Prior information may be used, e.g. original design documents, codes from the time of construction, product literature. Values for the basic variables should be evaluated taking into account new information, such as results from structural inspections; further requirements for condition surveys are also provided in sub-clause 5.6. Material testing may also be used, applying the statistical methods of EN 1990-1 Annex D to derive characteristic values from test data.

The actions Eurocode, EN 1991, does not include specific actions models for assessment. In place of such content, EN 1990-2 Annex I.4 provides guidance on applying actions from EN 1991 to an assessment. However, values other than those in EN 1991 can be relevant. For example, imposed loads on buildings may be based on actual use rather than applying design values. Similarly, assessment live load models for traffic for highways and railways are well established in the UK and are expected to remain in use.

Partial factor method

Clause 8 of EN 1990-2 is a short but fundamental section that defines application of the partial factor method, by invoking the partial factor method given in EN 1990-1. Additionally, EN 1990-2 contains various parts of Annex A relating to different structure types, including Annex A.1 for buildings and Annex A.2 for bridges, etc., with the idea that partial factors and combinations for assessment are defined in EN 1990-2 Annex A, and those for design are defined in EN 1990-1 Annex A.

In the UK National Annex, it is not expected that specific partial factor values will be provided in EN 1990-2 Annex A, due to the variety of different approaches that are currently used, e.g. referring to previous British Standards that are different for steel and concrete; and use of different client standards for highway and railway bridges. Instead, the decision is likely to remain with the relevant authority or specific project, and should be specified in the assessment approach. In the absence of client-specific requirements, or a decision on the specific project by the relevant parties, the design values of partial factors are used by default.

Clause 8 provides a framework of options for partial factors and combinations of actions, including defining the set of combinations to be used, use of a fixed set of partial factors or adjustment for a specific case, and values of partial factors. The Eurocode defaults are to use the same partial factors and combinations for assessment as for design. However, there is considerable flexibility in the NDPs, and, as above, the UK National Annex is likely to leave these decisions to the relevant authority or specific project, meaning that previous UK approaches to assessment can remain valid within the new Eurocode framework.

Assessment of Resistance (8.3.2) gives requirements for the resistance models. Since EN 1990 is not intended to contain material-specific content, instead it provides conditions for use of the resistance models in the material Eurocodes (e.g. EN 1992 for concrete). The material Eurocodes should be used if they define assessment resistance models (typically not the case for second-generation Eurocodes).

The design resistance models may be used if certain conditions are met, including that material properties, detailing and execution tolerances comply with the design requirements and that the structure is in good condition. Often these conditions will not be met for existing structures. In such cases, the National Annex can provide applicable resistance models. It is expected that the UK National Annex will allow relevant authorities or specific projects to determine appropriate resistance models for assessment, which could correspond with former codes used at the time of construction, could have been developed specifically to account for assessment of deteriorated structures, or could entail cautious adjustment of the Eurocode design resistance models.

Interventions

Clause 11 of EN 1990-2 contains principles for interventions. In particular, it includes requirements for replaced, new or additional structural members. The Eurocode default is to use the same requirements as for new design. However, this is a tricky area, particularly when retained parts of an existing structure have been assessed using assessment load models and resistance models and a new element takes loads from the existing structural system. Therefore, there is some flexibility permitted in the approach, but as a minimum, the new or additional structural members should meet the requirements for existing structures.

Discussion and conclusions

The second-generation Eurocodes will be implemented in the UK in March 2028, and contain new coverage of assessment of existing structures. The new basis of assessment, EN 1990-2, provides a framework within which assessments are undertaken.

This review of the second-generation Eurocode content for assessment of existing structures shows that there is generally good alignment between the Eurocode requirements and past UK practice. This good alignment is the result of considerable work and influence by UK experts operating at European level over many years, to make the content suitable for UK needs, while supporting the objectives of the Eurocode evolution programme.

The new Eurocode content gives future opportunities: the convergence of assessment and design provisions enables assessment of recently constructed structures; could enable future alignment of actions applied for assessment and design; and could more readily enable, where appropriate, use of relevant resistance models to improve assessment results. Moreover, the codification into a standard provides a consistent pan-European framework for assessment of existing structures.

The UK National Annex for EN 1990-2 is currently under development. It is anticipated that industry guidance and client documents will need to be updated for compatibility with the Eurocode framework, although it is expected that the underlying technical provisions could remain applicable, which means there can be some continuity in the resulting assessments, without a step change in the assessed capacity. Particularly when the significant choices within the Eurocode framework are determined for a specific project, the skill, experience and competence of practitioners to undertake assessment of existing structures will remain important.

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This article forms part of a series being developed by the IStructE and BSI to support the transition to the second-generation Eurocodes and promote industry readiness.

A series of videos explaining the evolution of the Eurocodes is also available at www.istructe.org/eurocodes/

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