Eurocode transition

Eurocodes evolution: basis of design

Mungo Stacy and Steve Denton explain the key technical changes and practical implications of the updates to basis of design in the second-generation suite of Eurocodes.

Introduction

This article continues the series of updates about transition to the second-generation Eurocodes[1]. It explains changes to BS EN 1990-1 *Basis of design*[2], which was published by the British Standards Institution (BSI) in March 2026, with the UK National Annex to BS EN 1990-1[3] subsequently published in September 2026.

Objectives

BS EN 1990 is the head standard in the Eurocode suite, and is relevant to every application of Eurocodes. It establishes principles and requirements for the safety, serviceability, robustness and durability of structures. In line with the objectives of the second-generation Eurocode programme, described in a previous article[4], the update is an evolution that aims to incorporate the latest technical understanding while enhancing ease of use. Therefore, the fundamental principles, such as the partial factor format, remain familiar, while inconsistencies from first-generation Eurocodes are addressed, such as a new combined approach that includes geotechnical structures.

Scope of basis of design

The first-generation BS EN 1990 has been split into two parts. The basis of design for new structures is now covered in BS EN 1990-1, corresponding to the first-generation BS EN 1990. The new BS EN 1990-2 provides a companion basis of assessment[5]. Some provisions of BS EN 1990-1 are also relevant for assessment, and are invoked when relevant from BS EN 1990-2.

A major change in scope is that BS EN 1990-1 now includes geotechnical structures, and this is reflected in the document title, 'Basis of structural and geotechnical design'. A key benefit is that BS EN 1997-1[6] no longer needs to include similar but adjusted provisions for geotechnical design, reducing the potential for confusion between BS EN 1990 and BS EN 1997. In particular, the formulae for effects of actions and design values of resistance now include all relevant terms for applications including ground materials **(Table 1)**.

Table 1: Consolidated basis of design for structural and geotechnical design

First generation		Second generation	
$E_d = E\{\gamma_{F,i} F_{rep,i}; a_d\}$	BS EN 1990 (6.2a)	$E_d = E\{\sum(\gamma_F \psi F_k); a_d; X_{Rd}\}$	BS EN 1990-1 (8.4)
$E_d = E\{\gamma_F F_{rep}; X_k/\gamma_M; a_d\}$	BS EN 1997-1 (2.6a)		

Application rules for buildings remain in BS EN 1990-1, Annex A.1 **(Figure 1)**, and for bridges in Annex A.2 **(Figure 2)**. Coverage has been extended for other structure types through additional clauses in Annex A: towers, masts and chimneys (Annex A.3); silos and tanks (Annex A.4); structures supporting cranes or machines (Annex A.5); coastal structures (Annex A.6). The recently published National Annex includes the nationally determined parameters for Annexes A.1 and A.2 for buildings and bridges; the parameters for Annexes A.3 to A.6 will follow in a future revision.

New content has been provided for bridges. In particular, Annex G defines for the first time a consolidated basis of design for bearings. Annex H sets out acceleration limits for footbridge vibration, although the National Annex retains the approach and limits previously given in the first-generation traffic actions National Annex.

Combinations of actions

A key role of BS EN 1990-1 is to define how to combine the values of actions that are considered to occur simultaneously. Many of the key concepts introduced in first-generation Eurocodes[7] remain applicable: verifications are undertaken for ultimate (ULS) and serviceability (SLS) limit states; combinations of actions are calculated for design situations including persistent, transient, accidental, seismic, fatigue; representative values of actions are selected depending on the limit state.

The combinations of actions for the ULS fundamental design situation are given by BS EN 1990-1, Formulae (8.12) to (8.14), which are reproduced as **Box 1**. Other than a minor change to the order of subscripts, Formula (8.12) is identical to the first-generation equation (6.10), and Formula (8.13) is identical to the first-generation equations (6.10a) and (6.10b). Formula (8.14), which omits the variable action term from the upper equation, was previously permitted by a footnote to the Set B partial factors table, and this option has now been given equal status to the other alternatives. However, in the UK, the usage remains the same as previously. For buildings, the UK National Annex allows either Formula (8.12) or Formula (8.13) to be used, with Formula (8.13) providing the more economical result. For bridges, the UK National Annex requires Formula (8.12) to be used.

The clauses of Annex A now provide



FIGURE 1: Application rules for buildings are given in EN 1990-1, Annex A.1



FIGURE 2: Application rules for bridges are given in EN 1990-1, Annex A.2

Box 1. Combination of actions for persistent and transient (fundamental) design situations

$$\sum F_d = \sum_i \gamma_{G,i} G_{k,i} + \gamma_{Q,1} Q_{k,1} + \sum_{j>1} \gamma_{Q,j} \psi_{0,j} Q_{k,j} + \left(\gamma_P P_k\right) \quad (8.12)$$

or

$$\sum F_d = \begin{cases} \sum_i \gamma_{G,i} G_{k,i} + \gamma_{Q,1} \psi_{0,1} Q_{k,1} + \sum_{j>1} \gamma_{Q,j} \psi_{0,j} Q_{k,j} + \left(\gamma_P P_k\right) \\ \sum_i \xi_i \gamma_{G,i} G_{k,i} + \gamma_{Q,1} Q_{k,1} + \sum_{j>1} \gamma_{Q,j} \psi_{0,j} Q_{k,j} + \left(\gamma_P P_k\right) \end{cases} \quad (8.13)$$

or

$$\sum F_d = \begin{cases} \sum_i \gamma_{G,i} G_{k,i} + \left(\gamma_P P_k\right) \\ \sum_i \xi_i \gamma_{G,i} G_{k,i} + \gamma_{Q,1} Q_{k,1} + \sum_{j>1} \gamma_{Q,j} \psi_{0,j} Q_{k,j} + \left(\gamma_P P_k\right) \end{cases} \quad (8.14)$$

convenient tables that show the factors that apply to the actions for the different limit states and combinations, e.g. BS EN 1990-1, Tables A.1.3 to A.1.6. In the first-generation Eurocode, these relationships could only be inferred from the equations themselves, and similar tables tended to be included in guidance documents and training.

Ultimate limit states and partial factors

In first-generation Eurocodes, the values of partial factors were defined in sets of three complex tables: Set A for static equilibrium (EQU), Set B for structural resistance (STR) and Set C for geotechnical resistance (GEO). In second-generation BS EN 1990-1, the partial factor values have been combined into single tables, e.g. Table NA.3 for buildings, Table NA.10 for bridges, giving the benefit that it is easier to read across and compare partial factor values across the different cases, and forcing the user to be clear on which case applies.

The three-letter designations EQU, STR, GEO are no longer used. Instead, the different cases are referred to as Verification Cases, VC1 to VC4. VC1 is the common case of structural or geotechnical resistance; VC2 applies when static equilibrium or uplift is being checked; VC3 and VC4 apply to geotechnical checks and are invoked in BS EN 1997. In VC1 to VC3, partial factors are applied to the individual actions, whereas VC4 is the only case where the total effect of actions is factored.

The National Annex includes concise tables for each verification case in Annex NA.B, to simplify application for designers undertaking design tasks in a single verification case. See, for example, **Table 2**, which reproduces Table NA.B.1, and provides partial factors for VC1 for structural resistance for buildings.

Consequence factors

The partial factors (e.g. as shown for VC1 in **Table 2**) include a consequence factor, k_F. The consequence factor is intended to allow for the possibility of reliability differentiation, that is, adjusting the partial factors depending on the consequence class of the structure. The concept of reliability differentiation was included in first-generation Eurocodes as an option in Annex B, so this is not new, but is expressed more prominently in the second-generation Eurocode.

Past UK practice for buildings and bridges has been that the same values of partial factors are used regardless of consequence class. Experience has not shown any particular need to increase the level of safety (through higher partial factors on loading) for high-consequence structures such as tall buildings or large bridges, and using invariant partial factors avoids the challenges that would arise at step-changes between categories.

The National Annex continues this past practice while addressing some matters of consistency (see **Table 3**, which replicates Table NA.4 for buildings; the approach for bridges is similar). The National Annex subdivides consequence classes such that the normal choice for structures in CC1 to CC3 is to provide a unity value of consequence factor k_F in line with past practice.

The National Annex indicates that CC1a and CC3b allow selection of lower or higher levels of reliability by exception through agreement with the relevant authorities on a specific project. CC1a is permitted for agricultural buildings with low human occupancy, thus bringing designs to BS 5502-22[8] within the Eurocode framework. CC1a can also apply for low-consequence geotechnical structures, in conjunction with a companion consequence factor for material properties, k_M, in BS EN

1997-1. The national decisions for towers and masts in Annex A.3 are still under development, but past UK practice in BS 8100-1[9] has applied reliability differentiation for partial factors on actions on towers and masts.

Static equilibrium, uplift, and the single source principle

The numerical values of partial factors in the National Annex are the same as for the first-generation Eurocode, with the exception of those for Verification Case VC2 for static equilibrium/uplift. The partial factors on permanent actions for VC2(a) are now greater than or equal to unity, rather than being balanced around unity as previously.

The reason for this change is to address difficulties that had been identified in using the first-generation EQU partial factors. For example, a case study[10] considers a beam subject to overturning, where the EQU verification identifies that a restraining anchor is needed to satisfy equilibrium, but the STR verification cannot determine the anchor force (i.e. the force obtained from the STR verification is less than zero).

The second-generation Eurocode Verification Case VC2 presents a combined structural resistance and static equilibrium/uplift check (previously noted as a possible special case[7]). For cases governed by permanent actions, static equilibrium depends on the ratio between the stabilising and destabilising permanent actions, and the National Annex sets the partial factors for VC2(a) keeping this ratio the same as previously under the first-generation EQU case. VC2(b) covers the case where variable actions are significant, when stability depends on the ratio between the stabilising permanent and the variable action. Under this approach, in cases when a restraining force is needed for stability, the restraining force is determined directly from the same verification case and is consistent with results for structural resistance from VC1 since the unfavourable and favourable partial factors are the same in VC1 and VC2.

The single-source principle receives better definition in the second-generation BS EN 1990-1, in the main text and Annex A. As described in Annex A, partial factors for destabilising and stabilising permanent actions should be applied when variations in the magnitude or spatial variation of permanent actions from a single source are significant (i.e. using VC2). Partial factors for unfavourable and favourable permanent actions should be applied when the permanent actions do not arise from the same single source.

Table 2: The National Annex provides a concise presentation of partial factors for each verification case; example here shown for structural/geotechnical resistance for buildings (verification case VC1) – reproduced from Table NA.B.1

		VC1 Structural/geotechnical resistance			
Type	**Group**	**Symbol**	**Unfavourable**	**Symbol**	**Favourable**
Permanent action (G_k)	All except water	γ_G	$1.35k_F$	$\gamma_{G,fav}$	1.0
	Water [A]	γ_{Gw}	$1.2k_F$ [A]		
Prestressing (P_k)		γ_P	See other relevant Eurocodes where γ_P is materially dependent		
Variable action (Q_k)	All except water	γ_Q	$1.5k_F$	$\gamma_{Q,fav}$	0.0
	Water [A]	γ_{Qw}	$1.35k_F$ [A]		

NOTE k_F = 1.0 for structures in consequence class CC1b, CC2, CC3a, see **NA.2.2.8**.

[A] For simplicity, the partial factors for water γ_{Gw} and γ_{Qw} may conservatively be taken the same as the other partial factors for permanent and variable actions respectively, i.e. γ_{Gw} the same as γ_G and γ_{Qw} the same as γ_Q. For groundwater, see BS EN 1997-1. For water actions induced by waves and currents, see BS EN 1990-1:2023+A1:2026, **A.6**.

Table 3: The National Annex subdivides consequence classes such that the normal choice for structures in CC1 to CC3 is to provide a unity value of consequence factor k_F – reproduced from Table NA.4 – Table A.1.9 (NA)

Consequence class (CC) [A]	Description of consequences	Consequence factor k_F [B]
CC3b	High (upper class)	1.1
CC3a CC2 CC1b	High (lower class) Normal (upper class) Low (upper class)	1.0
CC1a	Low (lower class)	0.9

[A] The provisions in Eurocodes cover design rules for structures classified as CC1 to CC3, see BS EN 1990-1:2023+A1:2026, **4.3**. For CC4 structures, additional provisions to those given in the Eurocodes are needed, e.g. reliability-based or risk-informed approaches.

[B] Values of k_F = 1.1 for CC3b or k_F = 0.9 for CC1a structures are used when specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties with appropriate justification.

Robustness

The selection of consequence class has two main uses in EN 1990-1: the selection of a consequence factor, as described above, and in the treatment of robustness. In EN 1997-1, consequence class is also used to determine geotechnical category in conjunction with the geotechnical complexity class.

Consequence classes for buildings are given in the National Annex, Table NA.1. The differentiation is used in particular with the requirements for horizontal and vertical ties to provide robustness, which are given in the National Annex, Annex NA.A, which replaces the informative Annex E in BS EN 1990-1. The National Annex requirements for robustness are consistent with Approved Document A, and take into account the emerging recommendations from the recent consultation on that document.

The content on strategies for robustness was previously in BS EN 1991-1-7 in the first-generation Eurocode, but has now been moved to BS EN 1990-1 since robustness is one of the fundamental requirements, listed in the first sentence of the scope of BS EN 1990-1. The nominal values of tie force action, and the internal explosion pressure of 34kPa, remain in BS EN 1991-1-7, Annex A, with values for tie forces for concrete structures given in BS EN 1992-1-1.

Competence, design checking, inspection during execution

BS EN 1990-1 relies on assumptions, given in BS EN 1990-1, 1.2, including that designers and constructors are competent; that there is control, checking and supervision of design and construction; that correct materials and products in accordance with design requirements are used; adequate maintenance; etc. Meanwhile, there is considerable focus on competence within the industry following the introduction of the Building Safety Act, and an emerging set of standards for competence and competence frameworks, such as BS 8670[11].

BS EN 1990-1, Annex B, provides a possible framework for technical management measures. During development of the National Annex, the view was taken that procedures to manage design and execution fall outside the core scope of BS EN 1990-1 (although are fundamental to achieving the intended design outcomes) and are evolving or already present in other areas; for example, independent design checking is mandated for bridges through client documents such as National Highways' CG 300[12] and Network Rail's NR/L2/CIV/003[13]. Therefore, the National Annex merely states that Annex B may be used as a basis to define project-specific requirements. However, it cannot practically be used in the form provided in BS EN 1990-1 without further definition of the expectations and implications of the relevant categories.

Reliability-based methods

BS EN 1990-1 primarily defines the partial factor method of limit state design. It includes an opening for the use of probabilistic methods, subject to agreement by the relevant authority or agreement for use on a specific project. BS EN 1990-1, Annex C, provides some guidance on reliability-based methods, and has been supplemented by a more extensive background report[14]. The expectation set out in the National Annex is that Annex C may be used for calibration purposes, for cases of actions not covered by the BS EN 1991 series, and in exceptional cases, where agreed for use on a specific project.

Design assisted by numerical methods

There is still some ongoing work at European level to produce a new Annex J to BS EN 1990-1 that will cover design assisted by numerical methods. This Annex will cover validation and verification of numerical models, the use of the 'direct' method where resistances are derived directly from the numerical model, and calibration of model factors for numerical models. This Annex is expected to be published as an amendment A2 to BS EN 1990-1 in September 2027, together with an associated technical report providing further guidance and examples, but this amendment will make minimal changes to other sections of BS EN 1990-1.

Discussion and conclusions

The second-generation Eurocodes will be implemented in the UK in March 2028. This article has described some of the significant technical changes in the second-generation basis of design, BS EN 1990-1, and its National Annex. The fundamental principles of design using the partial factor method will remain the same as in first-generation Eurocodes, but improvements have been made to address consistency between Eurocodes and usage issues identified with the first-generation documents. The National Annex has been published and aims at an outcome of similar numerical values as the first-generation decisions, other than where technically justified.

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Eurocode transition

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.

For further resources and updates, visit the IStructE's dedicated transition page at www.istructe.org/eurocodes/

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