

PAS 8812:2016

Temporary works – Application of European Standards in design – Guide



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Foreword

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This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

The PAS process enables a guide to be rapidly developed in order to fulfil an immediate need in industry. A PAS can be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Relationship with other publications

BSI and HS2 engaged with a number of construction industry stakeholders to identify areas in which it was felt that the industry could benefit from further standardization. This engagement resulted in the development of two BSI PAS publications sponsored by HS2 and the Temporary Works Forum, including this PAS and PAS 8811, *Temporary works – Client procedures – Code of practice* (in preparation), which gives recommendations for UK infrastructure client procedures with respect to temporary works construction projects, from planning through to removal.

A number of other areas were identified as benefitting from standardization. A wider programme of work is underway to develop a further two PASs:

- PAS 8810, *Tunnel design – Design of concrete segmental tunnel linings – Code of practice*, which makes recommendations for the design of concrete segmental tunnel linings. It covers design considerations from project inception through to the end of the service life of the tunnel.
- PAS 8820, *Alkali-activated cementitious material and concrete – Specification*, which specifies requirements for alkali activated cementitious binders for suppliers of alkali-activated binders, ready mixed concrete, engineers and architects, contractors, asset owners and end users.

Where Eurocodes are referenced in this PAS, it is assumed that they will be used in conjunction with the relevant UK national annexes.

Use of this document

During the preparation of this PAS, the steering group has been mindful of the significant improvements in industry practice made as a result of the experience gained following a series of significant temporary works failures in the 1970s that lead to the publication of the Bragg Report [1] and subsequently the development of BS 5975, *Code of practice for temporary works procedures and the permissible stress design of falsework*. Accordingly, the steering group has endeavoured to provide high-level guidance to aid designers who are familiar with previous permissible stress-based codes and the use of equipment and materials rated with a safe working load to make the transition to the current suite of limit state design standards, focusing particularly on the development of guidance on appropriate approaches to partial factors on actions and materials and aspects associated with structural stability.

As a guide, this PAS takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this PAS is presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Spelling conforms to *The Shorter Oxford English Dictionary*. If a word has more than one spelling, the first spelling in the dictionary is used.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a PAS cannot confer immunity from legal obligations.

0 Introduction

0.1 Definition of temporary works

Within the UK construction industry, temporary works are widely understood to comprise: “parts of the works that allow or enable construction of, protect, support or provide access to, the permanent works and which might or might not remain in place at the completion of the works”, as defined in BS 5975. This also corresponds to a large degree with the definition of “auxiliary construction works” as defined in BS EN 1991-1-6, *Eurocode 1 – Actions on structures – General actions – Actions during execution*.

0.2 Categories of temporary works

A broad range of structures can be categorized as temporary works. Table 1 sets out the six groups of temporary works identified for the purpose of this PAS. The examples given in Table 1 are intended to be illustrative rather than exhaustive.

Table 1 – Groups of temporary works relevant to this PAS

Group	Sub-group	Examples
Group 1	Falsework	Support to a partially completed structure (e.g. in situ and precast concrete, steelwork during assembly) Propping Façade retention Needling Flying shores Gantries/cantilever Service bridges Structures providing stability during construction, alteration or demolition
	Formwork	Vertical (wall and column) Soffits Sloping Arches Cantilever soffits Permanent formwork
	Simple advancing falsework/ formwork	Formwork travellers (horizontal) Climbing formwork (vertical) Advancing/launching formwork
	Access	Tied scaffolds Freestanding scaffolds Gantries Special scaffolds (e.g. underslung scaffolds)
	Protection	Hoardings Protection fans Temporary roofs

Table 1 – Groups of temporary works relevant to this PAS (*continued*)

Group	Sub-group	Examples
Group 2	Geotechnical	Trench and excavation support Tower crane bases Piling/crane mats Retaining walls Earthworks Foundations Cofferdams Horizontal and inclined propping Underpinning Ground anchors Haul/site roads
Group 3	Vehicle and pedestrian bridges and related works	Temporary bridges Propping trafficked bridges
Group 4	Underground	Tunnels/headings Shafts Chambers Tunnelling thrust pits
Group 5	Marine temporary works	Temporary quay walls Dolphins Access jetties Floating plant
Group 6	Other temporary structures	Bridge launching Heavy lift systems Moving of structures Protection decks Structural support to cranes or other lifting devices Erection gantries Hydraulic equipment Jacking

0.3 Typical features of temporary works and associated risks

The following typical features of temporary works and their conditions of service mean that they tend to be subjected to risks that might not apply to permanent works.

- a) They tend to be in place for a relatively short period of time and then removed and potentially reused.
- b) Elements and components can be reused numerous times within a project or across several projects throughout their service life, potentially making them vulnerable to misuse on site. As such, their inspection and maintenance history, particularly when there is a risk of fatigue damage, needs to be managed.
- c) They might have interfaces with the permanent works, both in terms of the loading that they are subjected to and how they are supported. In some cases, temporary works might be left in place after the completion of the permanent works without necessarily contributing to the resistance or stability of the permanent works.
- d) They tend to carry a greater proportion of variable actions than permanent works.
- e) Structural systems often have less redundancy and lower stiffness than permanent works and might therefore be vulnerable to accidental loads associated with site activities.
- f) They can be particularly susceptible to initial imperfections such as lack of fit, eccentricities, corrosion or damage resulting from previous use.
- g) Commonly a relatively short timescale is allocated for their design and procurement.
- h) Limited site investigation data might be available when establishing geotechnical parameters.
- i) The dominant variable action is typically expected to be encountered at its characteristic value during normal service, whereas in permanent works it would be expected to occur only rarely over the structure's design life.
- j) The party that undertakes the design of temporary works is often not involved in the design of the permanent works that they support and might only be involved in a particular aspect of the temporary works and therefore not have a full appreciation of project-wide issues. As such, communication and effective exchange of design data can pose significant challenges and risks unless communication lines and responsibilities are clearly established.
- k) The nature of the procurement process for temporary works might bring risks associated with:
 - 1) assumptions regarding construction sequence;
 - 2) design interfaces and communication of design assumptions; and
 - 3) competence of the organization(s) responsible for the safe design, erection, use and removal of the temporary works.

0.4 Continuity in best practice

This PAS recognizes the developments in the field of design and management of temporary works in the UK in the last forty years, in particular those that stemmed from the Bragg Report [1] and subsequently BS 5975, *Code of practice for temporary works procedures and the permissible stress design of falsework*, which has been and remains the reference standard for design of falsework in the UK over the last 30 years.

This PAS together with the companion document PAS 8811 (in preparation) therefore endeavours to provide continuity of good practice during the transition to European Standards through the following approaches.

- a) **Application of appropriate procedural controls.** Safe implementation of temporary works is reliant on the application of appropriate procedural controls as introduced in BS 5975 and recommended in PAS 8811. These procedural controls cover the full process, including the selection of appropriate design standards, the development of the initial concept, and the management of operations through the erection and operation phase to final decommissioning.
- b) **Appropriate transfer of key data and information.** A key theme identified within the Bragg Report [1] was the need for the appropriate transfer of key data and information across all phases of the design cycle through effective communication between all involved parties, including coordination between the designers of permanent and temporary works.
- c) **Continuity in the overall levels of safety.** The overall levels of safety for falsework design embedded in BS 5975 have proved to be necessary and largely successful. This PAS has endeavoured to establish guidance on appropriate partial factors for actions and material properties that do not erode this position.

- d) **Design for stability.** The introduction in BS 5975 of the requirement for falsework systems to be designed to resist a notional lateral destabilizing load when considering global and nodal stability has resulted in a significant improvement in the safety of such systems within the UK. The guidance provided in this PAS aims to maintain that legacy and, where relevant, suggests extending its application to other temporary works systems.

These European Standards are intended to supplement the Eurocodes and provide additional guidance for those engaged in the design of these categories of temporary works. Generally, they provide simplified approaches that are likely to produce more conservative designs than those resulting from the use of the Eurocodes alone. Although these simplified approaches are likely to be valid for the majority of straightforward applications, they might not be appropriate for complex applications or where there is an interaction with permanent works or geotechnical design.

0.5 European Standards for temporary works design

The Eurocodes (i.e. BS EN 1990 to BS EN 1999) provide common structural design rules for construction works. Although they focus on the design of permanent works, they give principles and requirements for structural safety, serviceability and durability, which are also relevant to temporary works. However, because of the different features of permanent and temporary works, the application of the Eurocodes to the design of temporary works needs to be considered carefully in order to ensure that levels of reliability and safety that have previously been considered appropriate to the design of temporary works are not compromised.

A great deal of published guidance on the application of the Eurocodes exists in the form of non-contradictory complementary information (NCCI), most of which is equally valid to both permanent and temporary works. However, only a limited amount is available that is specific to the development of temporary works solutions and in particular how to apply a limit state design approach to temporary works.

European product and execution standards written specifically for temporary works have been published alongside the Eurocodes, for example:

- a) BS EN 1004, *Mobile access and working towers made of prefabricated elements – Materials, dimensions, design loads, safety and performance requirements*;
- b) BS EN 1065, *Adjustable telescopic steel props – Product specifications, design and assessment by calculation and tests*;
- c) BS EN 12063, *Execution of special geotechnical work – Sheet pile walls*;
- d) BS EN 12810 (all parts), *Façade scaffolds made of prefabricated components*;
- e) BS EN 12811 (all parts), *Temporary works equipment*; and
- f) BS EN 12812, *Falsework – Performance requirements and general design*.

1 Scope

This PAS gives guidance on the application of European Standards to the design of temporary works in the UK when adopted voluntarily, required by the Public Procurement Directive [2] or stipulated by the client.

NOTE See also PAS 8811, Temporary works – Client procedures – Code of practice (*in preparation*).

It covers:

- a) interpretation of key design approaches applicable to all temporary works including:
 - 1) recommendations on suitable partial factors and combinations of actions;
 - 2) recommendations on appropriate analysis approaches;
 - 3) stability considerations;
 - 4) considerations on reuse of equipment, as in the case of proprietary equipment;
- b) relationship between the Eurocodes and other European Standards specifically associated with temporary works; and
- c) clarification of design requirements for identified groups of temporary works.

The aim of this PAS is to promote consistency in the design approach to temporary works and remove uncertainties for temporary works designers.

It does not cover issues relating to either the procedural control of temporary works covered in BS 5975 or specific requirements related to client procedures, which are covered in PAS 8811 (*in preparation*).

This PAS highlights issues to be taken into account by the temporary works designer when selecting the most appropriate standards to adopt, in relation to the transfer of key design data and information across all phases of the design cycle. This PAS is for use by practitioners in the field of structural and geotechnical design of temporary works.

This PAS provides non-contradictory complementary information (NCCI) with respect to existing standards and other relevant guidance documents.

2 Normative references

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

NOTE 1 Where Eurocodes are referenced in the PAS, it is assumed that they will be used in conjunction with the relevant UK national annexes.

NOTE 2 A more extensive list of reference publications for temporary works including normative references, informative references and further reading, is provided at Annex A.

Standards

BS EN 1990, *Eurocode – Basis of structural design*

BS EN 1991 (all parts), *Eurocode 1 – Actions on structures*

BS EN 1992 (all parts), *Eurocode 2 – Design of concrete structures*

BS EN 1993 (all parts), *Eurocode 3 – Design of steel structures*

BS EN 1995 (all parts), *Eurocode 5 – Design of timber structures*

BS EN 1996 (all parts), *Eurocode 6 – Design of masonry structures*

BS EN 1997 (all parts), *Eurocode 7 – Geotechnical design*

BS EN 1999 (all parts), *Eurocode 9 – Design of aluminium structures*

BS 5930, *Code of practice for ground investigations*

BS 5975, *Code of practice for temporary works procedures and the permissible stress design of falsework*

BS 6349 (all parts), *Maritime works*

BS EN 12811-1, *Temporary works equipment – Part 1: Scaffolds – Performance requirements and general design*

BS EN 12812, *Falsework – Performance requirements and general design*

BS EN 13374, *Temporary edge protection systems – Product specification – Test methods*

BS EN ISO 14688 (all parts), *Geotechnical investigation and testing – Identification and classification of soil*

BS EN ISO 14689-1, *Geotechnical investigation and testing – Part 1: Identification and classification of rock – Identification and description*

NA to BS EN 1990, *UK National Annex for Eurocode – Basis of structural design*

NA to BS EN 1991 (all parts), *UK National Annex to Eurocode 1 – Actions on structures*

NA to BS EN 1992 (all parts), *UK National Annex to Eurocode 2 – Design of concrete structures*

NA to BS EN 1993 (all parts), *UK National Annex to Eurocode 3 – Design of steel structures*

NA to BS EN 1995 (all parts), *UK National Annex to Eurocode 5 – Design of timber structures*

NA to BS EN 1996 (all parts), *UK National Annex to Eurocode 6 – Design of masonry structures*

NA to BS EN 1997 (all parts), *UK National Annex to Eurocode 7 – Geotechnical design*

NA to BS EN 1999 (all parts), *UK National Annex to Eurocode 9 – Design of aluminium structures*

Other publications

[NR1] HIGHWAYS ENGLAND. *Design Manual for Roads and Bridges (DMRB)*. Guildford: Highways England.

[NR2] NETWORK RAIL. NR/L2/CIV/003, *Engineering Assurance of Buildings and Civil Engineering works*. London: Network Rail, 2012.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purpose of this PAS, the terms and definitions given in BS 5975, PAS 8811 (in preparation), BS EN 1990 and the following apply.

NOTE For clarification of some key terms used for the design of temporary works to the Eurocodes, see Annex B.

3.1.1 European standards in the construction sector

NOTE The European standardization system comprises design standards (known as “Eurocodes”), product standards and execution standards, which are identified by the Euronorm prefix “EN”. The implementation of European Standards in the UK is identified by the prefix “BS EN”.

3.1.1.1 Eurocode

standard that gives structural design provisions for construction works

NOTE The Eurocodes which are implemented in the UK in conjunction with their National Annexes, include:

- a) BS EN 1990, Eurocode – Basis of structural design;
- b) BS EN 1991 (all parts), Eurocode 1 – Actions on structures;
- c) BS EN 1992 (all parts), Eurocode 2 – Design of concrete structures;
- d) BS EN 1993 (all parts), Eurocode 3 – Design of steel structures;
- e) BS EN 1994 (all parts), Eurocode 4 – Design of composite steel and concrete structures;
- f) BS EN 1995 (all parts), Eurocode 5 – Design of timber structures;
- g) BS EN 1996 (all parts), Eurocode 6 – Design of masonry structures;
- h) BS EN 1997 (all parts), Eurocode 7 – Geotechnical design;
- i) BS EN 1998 (all parts), Eurocode 8 – Design of structures for earthquake resistance; and
- j) BS EN 1999 (all parts), Eurocode 9 – Design of aluminium structures.

3.1.1.2 execution standard

standard that specifies requirements for workmanship, fabrication and erection tolerances during the execution of structures

NOTE For example, BS EN 13670 covers the execution of concrete structures and BS EN 1090-2 covers the execution of steel structures.

3.1.1.3 product standard

standard that establishes the specification, required physical and mechanical properties, testing methods and classification for constructions materials

NOTE For example, BS EN 338 covers structural timber, BS EN 10025 covers hot rolled structural steels and BS EN 206 covers concrete mixes.

3.1.2 equivalent horizontal force

horizontal force applied during the analysis of framed structures (i.e. structures which depend for stability on either direct bracing, upon the stiffness of members in bending, or combination thereof) as a simplifying tool to allow for initial imperfections and potential second order effects

NOTE 1 This is typically given as a percentage of the vertical actions applied to the structure.

NOTE 2 Different design standards use alternative terminology. As an example, BS EN 1993-1-1 calls this force “equivalent horizontal forces”, BS EN 1991-1-6 uses both “equivalent horizontal force” and “nominal horizontal force”, BS 5975 uses both “notional lateral force” and “horizontal disturbing force”.

3.1.3 safe working load (SWL)

maximum un-factored load that can be safely resisted by a piece of proprietary equipment

3.1.4 supported construction

elements of the permanent works that are supported by the temporary works

3.2 Symbols

For the purpose of this PAS, the following symbols apply.

A	accidental action	γ	partial factor
A_d	design value of an accidental action	γ_F	general term to identify the partial factor for an action
C_d	limiting design value of the corresponding serviceability criterion	$\gamma_{f,Ed}$	partial factor to account for uncertainty in the coefficient of friction when calculating the frictional force arising from sliding systems
C_{prob}	probability factor	$\gamma_{f,Rd}$	partial factor to account for uncertainty in the coefficient of friction when calculating the frictional restraint
C_{season}	seasonal factor	γ_G	partial factor for permanent actions
E_d	design value of the effects of actions	$\gamma_{G,inf}$	lower bound partial factor for favourable permanent actions
$E_{d,dst}$	design value of the effect of destabilizing actions	$\gamma_{G,sup}$	upper bound partial factor for unfavourable permanent actions
$E_{d,stab}$	design value of the effect of stabilizing actions	γ_M	partial factor for the calculation of the resistances of materials (product of γ_m and γ_{Rd})
F_d	design value of an action	γ_m	partial factor for the material property
F_k	characteristic value of an action	γ_p	partial factor for prestressing actions
F_{rep}	representative value of an action	γ_Q	partial factor for variable actions
$G_{dst;d}$	design value of destabilizing permanent vertical actions	γ_{Rd}	partial factor for resistance
G_k	characteristic value of a permanent action	μ	coefficient of friction
$G_{stab;d}$	design value of stabilizing permanent vertical actions	$\sigma_{stab;d}$	design value of stabilizing total vertical stress at the bottom of the soil column
$G'_{stab;d}$	submerged weight of the column	ψ	factor to derive the representative value of a variable action
N_d	design value of the reaction force normal to the surface	$\psi_0 \cdot F_k$	combination value of a variable action
P	value of a prestressing action	$\psi_1 \cdot F_k$	frequent value of a variable action
$Q_{dst;d}$	design value of destabilizing variable vertical actions	$\psi_2 \cdot F_k$	quasi-permanent value of a variable action
$Q_{k,1}$	characteristic value of the leading variable action		
$Q_{k,i}$	characteristic value of an accompanying variable action		
R_d	design resistance		
$S_{dst;d}$	design value of the seepage force in the column		
$u_{dst;d}$	design value of the destabilizing total pore water pressure at the bottom of the soil column		
X_d	design value of a material or product property		
X_K	characteristic value of a material or product property		

4 Designing temporary works to the Eurocodes

4.1 Scope of application

Clause 4 provides guidance for the design of all types of temporary works to the Eurocodes.

When temporary works are designed to the Eurocodes, the principles of limit state design, used in conjunction with the partial factor method, apply. Figure 1 gives a general overview of the partial factor method in the Eurocodes for structural design and provides a tool to navigate this clause.

NOTE Figure 1 does not cover geotechnical design to Eurocodes, which is covered in 6.2.

When using alternative approaches, as presented in European product and execution standards or in other technical documents, designers should take account of the basic assumptions of those publications and of the potential complications or conflicts arising from applying them, particularly where an interaction with the phasing of the permanent works is involved.

4.2 Basic requirements

Temporary works should be designed and engineered with the same degree of care and consideration as permanent works so that during their working life they have adequate structural resistance, serviceability, durability and robustness.

NOTE See BS EN 1990:2002+A1:2005, 2.1 for basic structural requirements.

Any client-specific requirements to be taken into account during the design of temporary works should be identified in the design brief and, if applicable, the design statement (e.g. *Guidance note: Early focus on temporary works and buildability* [3]).

4.3 Design situations

As part of the design process, all design situations that reflect the service conditions foreseen during the working life of the temporary works should be taken into account.

The following classes of design situation are relevant to temporary works (see BS EN 1990:2002+A1:2005, 3.2).

- a) **Persistent design situation**, where the structure is in its normal configuration during its working life.
- b) **Transient design situation**, where the structure is in an unusual configuration for a short period of time [e.g. during execution (construction) stages or when undergoing maintenance, alteration or dismantling].
- c) **Accidental design situation**, where the structure is or has been subjected to exceptional conditions (e.g. under impact, explosion or when the structural configuration is changed as a consequence of localized failure).

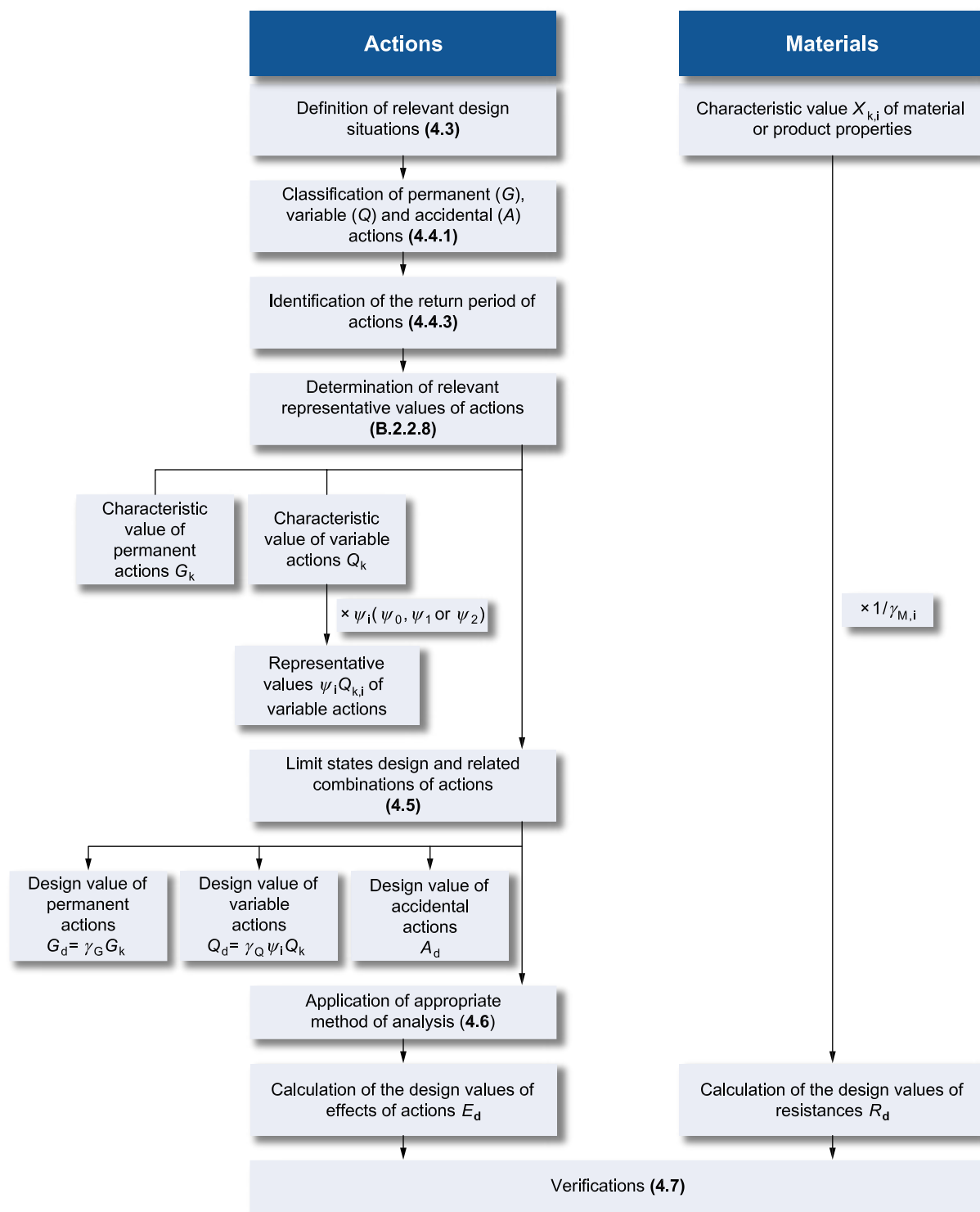
NOTE See BS EN 1991-1-6:2005, 3.1 for specific guidance on design situations during execution stages.

In practice, the same combination of actions is used for the verification of both persistent and transient design situations (see 4.5.2.1).

The relationship between permanent and temporary works can be complex. Permanent structures undergoing construction, maintenance, demolition or alteration should be considered in their temporary condition. Particular attention should be given to the distribution of load effects within both the permanent and temporary works and the potential effect on the stability of the combined system. The effect of the working methods and sequencing of construction activities should also be taken into account.

Where temporary works are to remain in place during a subsequent construction phase, the design information should be communicated to the designers of subsequent phases of the works in order to allow their effects on the structure in terms of stiffness and resistance to be fully considered.

Figure 1 – General overview of the partial factor method in the Eurocodes for structural design



4.4 Actions

4.4.1 Classification of actions

The following three main categories of actions should be taken into account when designing temporary works.

NOTE 1 *The specific actions indicated in the three categories below might be treated differently depending on their variability, duration and probability of occurrence. It is important that designers categorize actions appropriately and thus apply the appropriate partial factors to derive the design value of actions.*

- a) **Permanent actions.** Any action that remains in place over the service life of the structure. These include the self-weight of any structural elements or equipment incorporated into the temporary works, any ancillary elements connected to or forming part of the main temporary works structure (e.g. access ramps and platforms for access and storage of plant and materials, kentledge), earth pressure, groundwater pressure, and long-term effects such as creep, shrinkage and foundation differential settlements.

NOTE 2 *Creep and shrinkage are not normally significant for temporary works design.*

- b) **Variable actions.** These include supported construction, any actions that vary significantly in magnitude with time, such as associated construction loads (e.g. personnel with hand tools and equipment, formwork and its ancillary equipment), environmental actions, forces from the permanent structure (e.g. prestress effects), and equivalent horizontal force.

NOTE 3 *BS EN 1991-1-6 and BS EN 12812 consider supported construction as a variable action. However, the load that supported construction imposes on temporary works remains and is unlikely to change once in place as acknowledged by BS EN 12812. Therefore, it is important that particular attention is paid to the treatment of supported construction for different limit states. Specific recommendations are given at Annex C.*

- c) **Accidental actions.** These represent exceptional conditions that the structure would not be expected to cater for under normal service conditions and are usually the result of an extreme event such as impact or explosions.

NOTE 4 *See 6.6.4 for sources of impact on protection decks.*

4.4.2 Reference standards for actions

Table 2 provides a list of reference standards for typical actions on temporary works. This list includes Eurocodes and other European Standards that provide relevant information.

When using other European Standards, actions should be applied consistently with the assumptions of the standard being used.

NOTE *This is particularly important when these European Standards are applied in conjunction with the Eurocodes.*

4.4.3 Return periods of actions

4.4.3.1 General

Recommended return periods for the determination of the characteristic values of climatic actions during execution are given in BS EN 1991-1-6:2005, Table 3.1. These values depend on the nominal duration of the design situation being considered.

4.4.3.2 Specific guidance on wind actions

4.4.3.2.1 Basic wind velocity

The characteristic values of the basic wind velocity in BS EN 1991-1-4 are based on wind data with a return period of 50 years. To take account of a temporary structure being erected for a shorter period which is therefore less likely to be exposed to the characteristic wind, a probability factor c_{prob} and a seasonal factor c_{season} may be used.

NOTE 1 *The probability factor c_{prob} is introduced in BS EN 1991-1-4:2005+A1:2010, Expression (4.2).*

NOTE 2 *The seasonal factor c_{season} is introduced in BS EN 1991-1-4:2005+A1:2010, 4.2. Values of c_{season} are given in NA to BS EN 1991-1-4:2005+A1:2010, NA.2.7 for any possible one-, two-, and four-month periods during the year, as well as for the six-month summer and winter periods.*

Table 2 – Typical actions on temporary works and reference standards

Action type	Category	Typical actions on temporary works	Relevant standards
Permanent actions (G)	Self-weight	Self-weight of the temporary works, ancillary temporary works	BS EN 1991-1-1
	Earth pressure		BS EN 1991-1-6 BS EN 1997
	Groundwater pressure		BS EN 1997
Variable actions (Q)	Construction loads	Group 1: Supported construction	BS EN 1991-1-6 BS EN 1991-1-1 BS EN 12811-1 BS EN 12812 (falsework)
		Group 2: Personnel and hand tools Storage movable items Non-permanent equipment Movable heavy machinery and equipment Storage of materials Accumulation of waste materials	
	Environmental actions	Soil movements of the foundations of the structure and of temporary works	BS EN 1991-1-6 BS EN 1997
		Wind – maximum wind and working wind	BS EN 1991-1-6 BS EN 1991-1-4
		Snow	BS EN 1991-1-6 BS EN 1991-1-3 BS EN 12812
		Water and wave forces	BS EN 12812 BS 5975
		Atmospheric ice	BS EN 1991-1-6 BS EN 1993-3 BS EN 12812 ISO 12494
	Traffic loads		BS EN 1991-2 (bridges)
	Forces from the permanent structure	Prestressing	BS EN 1990 BS EN 1992 to 1999
		Pre-deformations	BS EN 1991-1-6 BS EN 1990 BS EN 1992 to 1999
		Temperature	BS EN 1991-1-6 BS EN 1991-1-5 BS EN 12812
		Shrinkage/hydration effects	BS EN 1991-1-6 BS EN 1992 to 1994
	Friction		BS 5975 BS EN 12812
	Equivalent horizontal force	Additional horizontal load equal to a given percentage of the vertical load	BS EN 1991-1-6 BS EN 12811-1 BS 5975
Accidental actions (A)	Accidental actions	Dynamic and impact forces	BS EN 1991-1-6 BS EN 1990 BS EN 1991-1-7

Any reduction to the wind action from its 50-year return period value requires careful consideration and should take into account:

- the context within which the temporary works are used and the resulting consequences of any failure;
- the potential total exposure period if a system or elements of it are reused multiple times; and
- the risk that the initial exposure period might be extended.

This is particularly important when applying c_{season} . Values of c_{season} less than unity should be applied only when there is control over the total exposure period.

NOTE 3 This recommendation is consistent with BS EN 1991-1-4:2005+A1:2010, 4.2 (3) which recommends that for transportable structures which might be used at any time in the year, c_{season} is taken equal to 1.

The rationale for any reduction to the wind action should be recorded in the design brief and, if applicable, the design statement.

4.4.3.2.2 Minimum wind speed

NA to BS EN 1991-1-6:2005, NA.2.5 allows a minimum wind speed to be used in the design of temporary works to be defined on a project-specific basis.

4.5 Limit state design

4.5.1 General criteria

For each critical load case, the design value of the effect of actions should be determined by combining actions that can occur simultaneously.

Where more than one variable action is considered to act simultaneously, the leading variable action should be identified for the purpose of establishing combinations of actions to give the greatest action effect.

NOTE 1 In some cases the choice of leading variable action might not be immediately evident and it might be necessary to treat each variable action in turn as a leading variable action to identify the most onerous for each verification.

In the case of temporary works, although supported construction is classified as a variable action, in practice once in place the load it imposes remains and should be considered as an accompanying variable action with a value of $\psi_0 = 1.0$ if the recommendations in Annex C are adopted. In which case, another variable action (e.g. other construction loads, wind) should be chosen as the leading variable action (see Figure B.1).

When designing to the Eurocodes, the general expressions for the combination of actions provided by BS EN 1990 should be used at the relevant ultimate limit state (see 4.5.2) and any applicable serviceability limit states (see 4.5.3).

NOTE 2 Some European product and execution standards provide different combinations of actions. In particular, BS EN 12811-1 and BS EN 12812 suggest specific load combinations for scaffolds and falsework systems respectively. For guidance on the scope of application of these load combinations, see 6.1.1 and 6.1.3.

Details of the structural configuration, critical load cases and combinations of actions to be applied to the temporary works at different stages of construction and any accidental design situations to be considered should be set out in the design statement.

4.5.2 Combinations of actions for ultimate limit states

4.5.2.1 Persistent and transient design situations

The fundamental combination of actions for ultimate limit state verifications of both persistent and transient design situations is given by BS EN 1990:2002+A1:2005, Equation (6.10):

$$\sum_{j \geq 1} \gamma_{G,j} G_{k,j} + \gamma_P P + \gamma_{Q,1} Q_{k,1} + \sum_{i \geq 2} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \quad (6.10)$$

where:

$\sum_{j \geq 1} \gamma_{G,j} G_{k,j}$	represents factored permanent actions;
$\gamma_P P$	represents factored prestress;
$\gamma_{Q,1} Q_{k,1}$	represents the factored leading variable action;
$\sum_{i \geq 2} \gamma_{Q,i} \psi_{0,i} Q_{k,i}$	represents factored accompanying variable actions at their combination value.

BS EN 1990 also introduces Equations (6.10a) and (6.10b), which are not equivalent to Equation (6.10) in terms of reliability level. For the design of temporary works, Equation (6.10) should be used in all cases.

NOTE See Designers' Guide to EN 1990 for background information on Equations (6.10), (6.10a) and (6.10b).

Values of partial factors γ and ψ factors should be obtained from Annex C.

4.5.2.2 Accidental design situations

The combination of actions for accidental design situations is given by BS EN 1990:2002+A1:2005, Equation (6.11b):

$$\sum_{j \geq 1} G_{k,j} + P + A_d (\psi_{1,1} \text{ or } \psi_{2,1}) Q_{k,1} + \sum_{i \geq 1} \psi_{2,i} Q_{k,i} \quad (6.11b)$$

where:

$\sum_{j \geq 1} G_{k,j}$ represents un-factored permanent actions;

P represents un-factored prestress;

A_d represents the design value of the accidental action;

$(\psi_{1,1} \text{ or } \psi_{2,1}) Q_{k,1}$ represents the un-factored main accompanying variable action at its frequent or quasi-permanent value;

$\sum_{i \geq 1} \psi_{2,i} Q_{k,i}$ represents the un-factored accompanying variable actions at their quasi-permanent value.

As well as considering the influence of the design value of the accidental action (A_d), it might be appropriate to take into account any damaged structural members which might need to be removed from the structural analysis.

The choice between $\psi_{1,1}$ and $\psi_{2,1}$ for the main accompanying variable action is given in the National Annex. In the UK, the National Annex to BS EN 1990 suggests the application of $\psi_{1,1}$ for buildings and bridges. $\psi_{1,1}$ should be applied to the main accompanying variable action for the design of temporary works in accidental design situations.

Values of ψ factors should be obtained from Annex C.

4.5.3 Combinations of actions for serviceability limit states

4.5.3.1 General

Serviceability limit state requirements should be agreed on a project-specific basis and based on the performance requirements for the temporary works being designed. The applicable limiting serviceability criteria should be stated in the design brief and, if applicable, the design statement, along with the appropriate combination of actions to be used during the verification.

4.5.3.2 Characteristic combination

In the general context of the Eurocodes, the characteristic combination of actions is used for verifying what the Eurocodes term “irreversible” serviceability limit state checks, which include stress limitations to ensure that yield criteria are satisfied over the full design working life.

The characteristic combination of actions is given by BS EN 1990:2002+A1:2005, Equation (6.14b):

$$\sum_{j \geq 1} G_{k,j} + P + Q_{k,1} + \sum_{i \geq 1} \psi_{0,i} Q_{k,i} \quad (6.14b)$$

where:

$\sum_{j \geq 1} G_{k,j}$ represents un-factored permanent actions;

P represents un-factored prestress;

$Q_{k,1}$ represents un-factored leading variable action at its characteristic value;

$\sum_{i \geq 1} \psi_{0,i} Q_{k,i}$ represents un-factored accompanying variable actions at their combination value.

NOTE The characteristic combination of actions mostly mirrors the combination prescribed for ultimate limit state verifications of persistent and transient design situations (BS EN 1990:2002+A1:2005, Equation (6.10)), the key difference being that no partial factors are applied to the actions. This means that it is an onerous combination in as much as it specifies that all actions are acting at their characteristic or combination value.

Values of ψ factors should be obtained from Annex C.

4.5.3.3 Frequent combination

In the general context of the Eurocodes, the frequent combination of actions is used for the evaluation of “reversible” serviceability limit states. It is used for crack-width checks for prestressed elements with bonded tendons. It is unlikely that it will be applicable in most temporary works designs.

The frequent combination of actions is given by BS EN 1990:2002+A1:2005, Equation (6.15b):

$$\sum_{j \geq 1} G_{k,j} + P + \psi_{1,1} Q_{k,1} + \sum_{i \geq 1} \psi_{2,i} Q_{k,i} \quad (6.15b)$$

where:

$\sum_{j \geq 1} G_{k,j}$ represents un-factored permanent actions;

P represents un-factored prestress;

$\psi_{1,1} Q_{k,1}$ represents un-factored leading variable action at its “frequent value”;

$\sum_{i \geq 1} \psi_{2,i} Q_{k,i}$ represents un-factored accompanying variable actions at their quasi-permanent value.

Values of ψ factors should be obtained from Annex C.