BS EN 12812:2008

BSI Standards Publication

Falsework — Performance requirements and general design

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 12812:2008. It supersedes BS EN 12812:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/514, Access and support equipment.

The design methodology within BS EN 12812:2008 is significantly different from that in BS 5975. Technical Committee B/514 advises that caution should be taken when applying BS EN 12812:2008.

BS EN 12812:2008 specifies performance requirements for the design of falsework in accordance with one of three classes: A, B1 and B2. Limit state design methods are specified for design Classes B1 and B2. It does not provide guidance for the structural design of Class A.

BS 5975, which exists in parallel with this standard and provides recommendations on the design of falsework, without definition of classes or physical parameters and using permissible stress methods, is re commended by Technical Committee B/514 as a suitable method for the structural design of Class A falsework, as defined in BS EN 12812:2008.

The 'Bragg Report', published in 1975 by the Advisory Committee on Falsework, first introduced a minimum lateral stability force. This force was subsequently incorporated, as a minimum horizontal disturbing force of 2.5 % of the applied vertical load in BS 5975, assuming first-order analysis. Technical Committee B/514 advises that the application of this force has made a significant contribution to the safe use of falsework in the UK since its introduction. Technical Committee B/514 also advises that BS EN 12812:2008 does not recommend a minimum horizontal force.

BS EN 12812:2008 does not provide guidance on procedures necessary for the successful management of work on site. The recommendations of the 'Bragg Report' in respect of the falsework coordinator have not been included in it.

BS 5975 includes procedural controls for all temporary works, including falsework, for the design, independent checking of the design, and for the successful management of work on site, including the appointment of a temporary works coordinator. Technical Committee B/514 reaffirms the importance of these controls.

This standard contains a National Annex NA that provides informative guidance on its application. It should be noted that there are a number of textual and numerical differences between the 2004 and 2008 editions; only those that are considered to be material are commented on in the National Annex NA. It is therefore not a comprehensive listing of all of the differences. Further, the UK committee advises that the symbols used in this standard should be read with caution.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

ISBN 978 0 580 60505 5

ICS 91.220

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12812

July 2008

ICS 91.220

Supersedes EN 12812:2004

English Version

Falsework - Performance requirements and general design

Etaiements - Exigences de performance et méthodes de conception et calculs

Traggerüste - Anforderungen, Bemessung und Entwurf

This European Standard was approved by CEN on 7 June 2008.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 12812:2008: E

Contents

Page

Foreword

This document (EN 12812:2008) has been prepared by Technical Committee CEN/TC 53 “Temporary works equipment”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2009, and conflicting national standards shall be withdrawn at the latest by January 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12812:2004.

This European Standard is one of a package of standards that includes also EN 12810-1, EN 12810-2, EN 12811-1, EN 12811-2, EN 12811-3, EN 12813.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Most falsework is used:

— to carry the loads due to freshly poured concrete for permanent structures until these structures have reached a sufficient load bearing capacity;

— to absorb the loads from structural members, plant and equipment which arise during the erection, maintenance, alteration or removal of buildings or other structures;

— additionally, to provide support for the temporary storage of building materials, structural members and equipment.

This European Standard gives performance requirements for specifying and using falsework and gives methods to design falsework to meet those requirements. Clause 9 provides design methods. It also gives simplified design methods for falsework made of tubes and fittings. The information on structural design is supplementary to the relevant Structural Eurocodes.

The standard describes different design classes. This allows the designer to choose between more or less complex design methods, while achieving the same level of structural safety.

Provision for specific safety matters is dealt with in EN 12811-1 and other documents.

1 Scope

This European Standard specifies performance requirements and limit state design methods for two design classes of falsework.

It sets out the rules that have to be taken into account to produce a safe falsework structure.

It also provides information for falsework which is required to support a "permanent structure", or where the design or supply of falsework has to be commissioned.

This European Standard also gives information on foundations.

This European Standard does not specify requirements for formwork, although formwork may be a part of the falsework construction. Nor does it provide information on access and working scaffolds, which is given in EN 12811-1.

This European Standard does not provide information about site activities. It does not provide information about the use of some standardized products, including timber formwork beams conforming to EN 13377 and props conforming to EN 1065.

2 Normative references

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

EN 74-1, *Couplers, spigot pins and baseplates for use in falsework and scaffolds — Part 1: Couplers for tubes — Requirements and test procedures*

prEN 74-2, *Couplers, spigot pins and baseplates for use in falsework and scaffolds — Part 2: Special couplers — Requirements and test procedures*

EN 74-3, *Couplers, spigot pins and baseplates for use in falsework and scaffolds — Part 3: Plain base plates and spigot pins — Requirements and test procedures*

EN 1065:1998, *Adjustable telescopic steel props — Product specifications, design and assessment by calculation and tests*

EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*

EN 1090-3, *Execution of steel structures and aluminium structures - Part 3: Technical requirements for aluminium structures*

EN 1990, *Eurocode — Basis of structural design*

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

EN 1993-1-1:2005, *Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings*

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

EN 1998 (all parts), *Eurocode 8 — Design of structures for earthquake resistance*

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

EN 12810-1:2003, *Facade scaffolds made of prefabricated components — Part 1: Product specification*s

EN 12811-1:2003, *Temporary works equipment — Part 1: Scaffolds — Performance requirements and general design*

EN 12811-3, *Temporary works equipment — Part 3: Load testing*

EN 12813, *Temporary works equipment - Load bearing towers of prefabricated components - Particular methods of structural design*

EN 13377**,** *Prefabricated timber formwork beams — Requirements, classification and assessment*

3 Terms and definitions

For the purposes of this document, the terms and definitions in EN 1993-1-1:2005 and the following apply.

3.1
brace
component connecting two points of a structure to help stiffen it

3.2
design class
class that defines the extent of design for falsework

3.3
falsework
temporary support for a part of a structure while it is not self-supporting and for associated service loads

3.4
formwork
part of temporary works used to give the required shape and support to in-situ concrete

3.5
foundation
sub-structure needed to transmit loads into the ground

3.6
kentledge
material placed on a structure to provide stability by the action of its dead weight

3.7
imperfections
initial out of straightness (bow imperfection) or out of verticality (sway imperfection) of a structural component or of the structure used for calculations

NOTE 1 A bow imperfection can occur both in an individual member and in the complete tower or modular beam assembly. It arises because the member is not straight, is manufactured not straight or members are assembled out of alignment.

NOTE 2 These are the values for design purposes and may be more than the erection tolerance.

3.8
node
theoretical intersection point of members

3.9
sway
angular deflection of a column or other structure caused by the application of load

4 Design classes

4.1 General

The design shall be in accordance with one of the classes: A or B. Class B has two subclasses, B1 and B2, see 4.3 where the designer has to decide which subclass shall be applied.

4.2 Design class A

NOTE A Class A falsework is one which follows established good practice which may be deemed to satisfy the design requirements.

Class A covers falsework for simple constructions such as in situ slabs and beams.

Class A shall only be adopted where:

a) slabs have a cross-sectional area not exceeding 0,3 m^2 per metre width of slab;

b) beams have a cross-sectional area not exceeding 0,5 m^2;

c) the clear span of beams and slabs does not exceed 6,0 m;

d) the height to the underside of the permanent structure does not exceed 3,5 m.

The design for class A falsework shall be in accordance with the descriptive requirements in Clauses 5 and 7.

4.3 Design class B

Class B falsework is one for which a complete structural design is undertaken. Class B falsework is required to be designed in accordance with the relevant Eurocodes. There are separate additional provisions in this code for Classes B1 and B2 that are detailed below. Class B2 uses a simpler design method than Class B1 to achieve the same level of safety.

4.3.1 Class B1

The design shall be in accordance with the relevant Eurocodes (EN 1990, EN 1991 to EN 1999) and additionally with 9.1.1, 9.1.2.1, 9.1.3, 9.3.3 and 9.4.1 of the present standard.

NOTE It is assumed that the erection will be carried out to the level of workmanship appropriate for permanent construction, see EN 1090-2 and EN 1090-3 for metal structures.

4.3.2 Class B2

The design shall be in accordance with Clauses 5, 6, 7, 8 and 9, with the exception of 9.1.2.1, 9.3.3, 9.4.1, and with the relevant Eurocodes (EN 1991, EN 1990 to EN 1999). Where there is a conflict, the provisions of the present standard shall take precedence.

NOTE Attention is drawn to the simplified methods given in 9.3 and 9.4 and to the requirements for drawings and other documentation given in 9.1.2.

5 Materials

5.1 General

Only materials that have established properties and that are known to be suitable for the intended use shall be used.

5.2 Basic requirements for materials

5.2.1 Materials shall comply with European product Standards; where they do not exist national standards shall be used.

5.2.2 Where the relevant properties of materials and equipment cannot be obtained from the standards referred to in 5.2.1, their properties shall be established by testing (see 9.5.2).

5.2.3 Steel of deoxidation type FU (Rimming steel) shall not be used.

5.3 Weldability

The steel used shall be weldable, unless structural members and components are not intended to be welded. Welding shall be carried out in accordance with the requirements of EN 1090-2 and EN 1090-3.

The design shall not require any welding of aluminium to be undertaken on site.

6 Brief

The design shall be based on a brief containing all necessary data including information on erection, use, dismantling and loading.

NOTE 1 Concrete is a typical example of loading.

NOTE 2 Adequate information about site conditions should be obtained and included in the brief. Particular points are:

- layout with levels, including adjacent structures;
- general appreciation of the parameters relating to wind load calculations for the local conditions;
- positions of services such as water pipes or electricity cables;
- requirements for access and safe working space;
- information about the ground conditions.

7 Design requirements

7.1 General

The structure shall be designed such that all the loads acting on it are carried into the subsoil or into a load-bearing sub-structure.

The available skill in erection and the ambient circumstances should be taken into account in the design.

Provision shall be made for the means of access for erection, use and dismantling. Reference shall be made to EN 12811-1.

The design should be based on concepts and details which ensure a practicable realization and which are straightforward for on site checks.

7.2 Thickness of material

7.2.1 Thickness of steel and aluminium components

The nominal thickness shall be not less than 2 mm.

7.2.2 Steel scaffold tubes

Loose steel tubes to which it is possible to attach couplers conforming to EN 74-1, prEN 74-2 and baseplates and spigots conforming to EN 74-3 shall be in accordance with EN 12811-1:2003, 4.2.1.2.

Tubes for incorporation in prefabricated components to which it is possible to attach couplers conforming to EN 74-1, prEN 74-2 and baseplates and spigots conforming to EN 74-3 shall be in accordance with EN 12811-1:2003, 4.2.1.3 and with EN 12810-1:2003, Table 2.

7.2.3 Aluminium scaffold tubes

Loose aluminium tubes to which it is possible to attach couplers conforming to EN 74-1, prEN 74-2 and baseplates and spigots conforming to EN 74-3 shall be in accordance with EN 12811-1:2003, 4.2.2.1.

7.3 Connections

7.3.1 Connection devices

Connections shall be designed such that they cannot be disconnected unintentionally when in use.

Vertical spigot connections between hollow sections in compression without additional means of fixing shall be deemed to be secure against unintentional disconnection if the overlapping length is not less than 150 mm.

7.3.2 Overlap of loose base jacks and head jacks with tube

The overlap length of the jack in the tube, l_0 (see 9.3.2), shall be either 25 % of the jack length, l_1, or 150 mm, whichever is the greater.

7.4 Flexibility of prefabricated support towers

A prefabricated support tower shall have a design capacity, R_d*, of 90 % of its normal design load bearing capacity, R_d, when a differential settlement, δ_s, has been imposed or when a thermal movement of the supported construction has caused a horizontal movement, δ_t (see Figure 1), which the tower shall accommodate.

The value of the settlement, δ_s, shall be the lesser of 5 mm and that calculated from Equation (1); the maximum value of the thermal movement shall be calculated from Equation (2) taking the lesser of the two values of δ_s from the previous examination.

$$\delta_s = 2,5 \times 10^{-3} \times l \leq 5 \text{ mm} \quad (1)$$

$$\delta_t = \delta_s \times h/l \qquad (2)$$

where

R_d is the normal design value of the load bearing capacity;

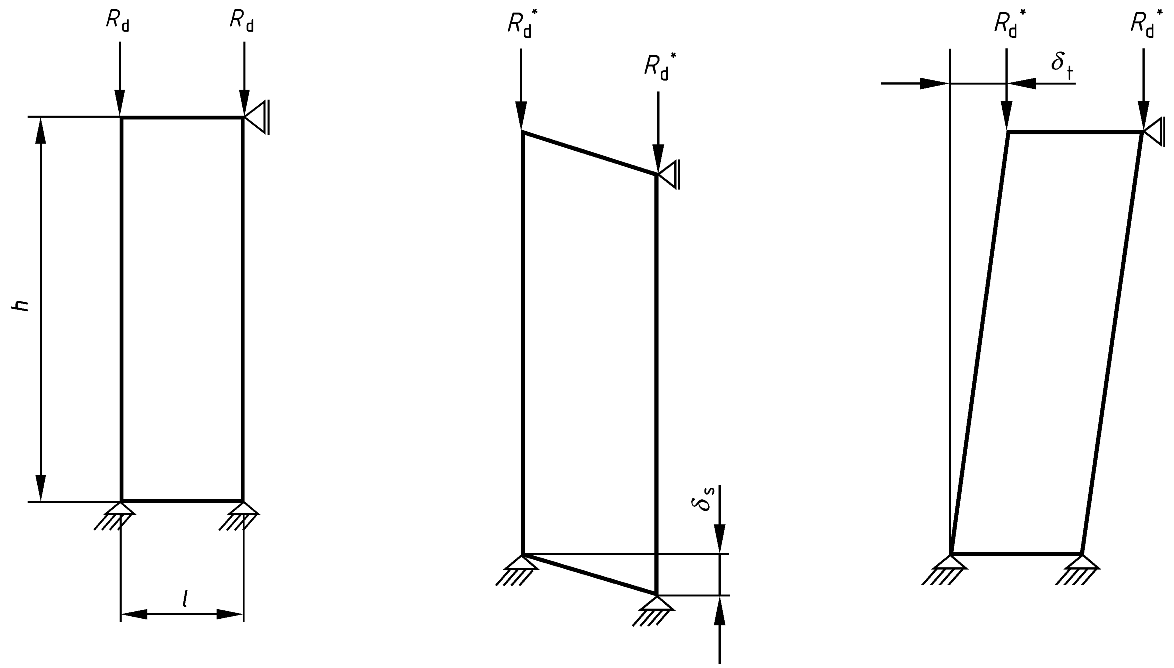
$R_d{}^*$ is the design value of the load bearing capacity after differential settlement or thermal movement has occurred;

h is the overall height of the tower in millimetres;

l is the horizontal base of the support tower in millimetres;

δ_s is the differential settlement;

δ_t is the horizontal movement caused by temperature.



a) Theoretical system b) Differential settlement c) Thermal movement

NOTE See 7.4 for symbol definitions.

Figure 1 — Relative deformations due to differential settlement or thermal movement

7.5 Foundation

7.5.1 Basic requirements for foundations

The structure shall be supported directly from one or more of the following:

— a sub-structure provided for the purpose;

- the surface of the existing ground, e.g. rock;
- a partly excavated and prepared surface, e.g. in soil;
- a structure which already exists;
- foundation according to 7.5.2.

Except where the conditions described in 7.5.2 apply, design shall follow the Eurocodes taking account of the expected life of the structure.

7.5.2 Support without any embedment in the ground

For a spread foundation, topsoil shall always be removed.

The foundation shall not be placed directly on such a levelled surface without embedment unless all of the following conditions are met:

- the foundation is made secure against degradation by surface water and ground water during the life of the falsework;

  NOTE 1 This may be done by providing drainage or protecting the surface with a concrete skin.

- it is known that frost is not likely to occur, which might affect permeable ground during the life of the falsework;
- either the support of the foundation is within 8 % of horizontal or, if the average slope exceeds 8 %, there is provision to transmit any component of force down the slope either to a thrust block or by other means, dissipating the force to the ground;
- in the case of cohesive soils, and where the distance to the edge is large, provision is made for drainage below the foundation slab;
- in the case of non-cohesive soils, the ground water level is not likely to rise to within 1 m of the bottom of the structure;

  NOTE 2 The object of this limitation is to keep settlement to a sufficiently low value.

- lateral shear capacity is verified.

7.5.3 Support from an existing permanent structure

The resistance of the permanent structure to the applied loads from the falsework shall be verified.

7.5.4 Stacked squared members

Stacked members consisting of rectangular timber elements or comparable components may be used:

- for the support construction for load bearing towers;
- for the height adjustment of the base-construction in combination with the foundation.

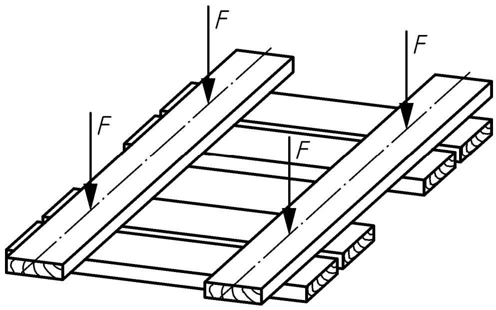
In each case, stacked members shall be placed crosswise, and the base area shall be enlarged with every layer from top to bottom. The support construction for load bearing towers shall cover the whole cross-section of the tower (Figure 2a).

The top-end of the stacked members shall be designed as a horizontal restrained bearing point or, by means of horizontal bracings, the bearing point is to be stabilized in any horizontal direction.

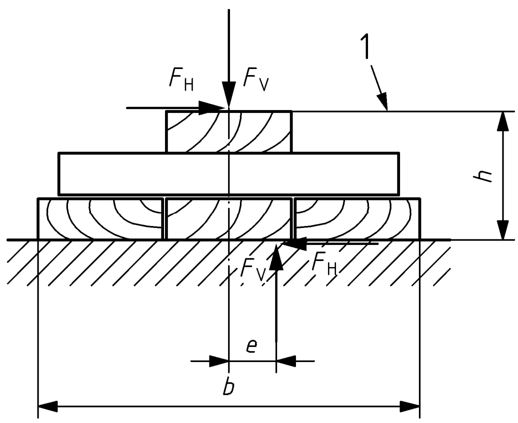
The stacked member is deemed to be a horizontal restrained bearing point, if the following condition is met:

$$e = \frac{F_H \cdot h}{F_V} \leq \frac{b}{6} \qquad h \leq 40\text{cm} \qquad (3)$$

For $F_H, F_V, h \text{ and } b$ see Figure 2.b).



a) support of a load bearing tower by stacked members



Key

1 lower edge of base plate

b) stacked member for height adjustment

Figure 2 — Examples of arrangement of stacked members

7.6 Towers providing support

The cross-sectional shape of a support tower shall be maintained e.g. by bracing or stiffened planes; at the top and bottom, the formwork and the foundation may substitute for the bracing if appropriately connected.

8 Actions

8.1 General

Typical actions on falsework, direct and indirect (Q_1 to Q_8), are described in the following subclauses. Where appropriate for a specific project, account shall be taken of other loading conditions (Q_9), e.g. the action due to mechanical plant moving. The values Q_1 to Q_9 are characteristic values of actions.

8.2 Direct actions

8.2.1 Permanent actions "Q_1"

8.2.1.1 Self-weight

The self-weight shall be taken into account.

NOTE Self-weight includes:

a) the falsework structure;

b) the formwork where applicable;

c) kentledge.

8.2.1.2 Soil

Lateral ground pressure shall be calculated in accordance with EN 1997.

8.2.2 Variable imposed actions

8.2.2.1 Variable persistent vertical imposed actions "Q_2"

8.2.2.1.1 Supported construction

Where other information is not available, the load from the permanent structure or other items to be supported shall be calculated from the volume and density of the material. In the case of concrete, this shall include the reinforcement.

For normal reinforced fresh concrete, the density shall be taken as 2 500 kg/m^3.

NOTE For design purposes, this may be taken as equivalent to 25 kN/m^2 per metre depth.

8.2.2.1.2 Storage areas

For design purposes, uniformly distributed loads due to material shall be deemed to be either the actual storage pressure or 1,5 kN/m^2, whichever is the greater. This provision shall extend either over the whole of the working area, or to a specifically designated area marked on the falsework.

8.2.2.1.3 Construction operations loading – operatives

A minimum live load allowance of 0,75 kN/m^2 shall be taken into account for all access and working areas supported by falsework. For example, this shall be applied to the platforms on a travelling cantilever bridge falsework unit while being moved forward.

NOTE A higher loading can be appropriate depending on the work to be carried out. Reference should be made to EN 12811-1.

8.2.2.1.4 Snow and ice

The loading from snow and ice shall be taken into account when it is expected to exceed 0,75 kN/m^2.

NOTE In conditions when there is high humidity and rain or snow and the structure is below freezing point, icing can occur. In such a case an allowance should be made. Maximum ice density is 920 kg/m^3.

For the purposes of calculating the horizontal force from floating ice, it shall be deemed to be debris (see 8.2.5.2).

8.2.2.2 Variable persistent horizontal imposed actions "Q_3"

A horizontal load equal to 1 % of the vertical load shall be taken into account applied externally at the point of application of the vertical load Q_2 in addition to the effects caused by imperfections (see 9.3).

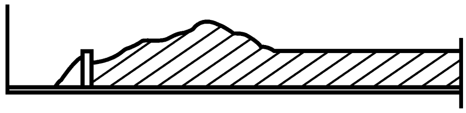
This external load shall be deemed to be taken through the structure to a point of adequate external restraint, generally to the underside of the falsework foundations.

8.2.3 Variable transient imposed actions, "Q_4"

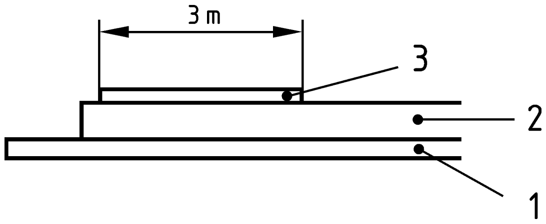
8.2.3.1 In-situ concrete loading allowance

Where in-situ concrete is to be placed, a live load allowance additional to that specified in 8.2.2.1.3 shall be adopted, making the total additional load equal to 10 % of the self-weight of the concrete of the casting segment. In no case shall the additional allowance be less than 0,75 kN/m^2 nor need it be greater than 1,75 kN/m^2. This additional load shall be deemed to act on a square area of plan size 3 m $\times$ 3 m, see Figure 3.

Where the concrete thickness is not constant over the area of 3 m $\times$ 3 m, an average value shall be adopted as the basis for calculating the self-weight.



a) Cross section during concreting



b) Loading diagram

Key

1 access areas: minimum live loading class 1 of EN 12811-1

2 loading from the weight of concrete to be supported

3 surcharge allowance for heaping during placing concrete

Figure 3 — Loading from concrete on falsework

8.2.3.2 Concrete pressure

Lateral concrete pressure shall be considered in the design.

NOTE The National Annex may give information on lateral loads. Published guidance can be found in:

— DIN 18218:1980;

— CIRIA Report No. 108, *Concrete pressure on formwork*, 1985;

— *Manual de Technologie: Coffrage*; CIB-FIB-CEB 27-98-83.

8.2.4 Wind "Q_5"

8.2.4.1 Maximum wind

Data shall be obtained from EN 1991-1-4, which gives velocity pressure for a 50-year return period.

NOTE The velocity pressure may be modified according to EN 1991-1-4 taking the period of use of the falsework into account.

8.2.4.2 Working wind

For the working wind, a velocity pressure of 200 N/ m^2 shall be used.

8.2.5 Flowing water actions "Q_6"

8.2.5.1 Loads produced by flowing water

The static pressure taken to represent the dynamic pressure of flowing water, q_w in Newtons per square metre, shall be calculated from Equation (4):

$$q_w = 500 \times v_w^2 \qquad (4)$$

where

v_w is the speed of water flow, in metres per second.

The load caused by water flowing around members, F_w, in Newtons, shall be calculated from Equation (5):

$$F_w = q_w \times \eta \times A \tag{5}$$

where

A is the effective area normal to the flow, in square metres;

η is the force coefficient for water appropriate to the members under consideration.

The effective water area A should be determined after investigating the maximum flood level.

NOTE 1 The following are some values of η:

— 1,86 for flat surfaces normal to flows;

— 0,63 for cylindrical surfaces;

— 0,03 for well streamlined surfaces.

NOTE 2 Shielding may be taken into account providing the structure is so arranged that a clear-cut water pattern is developed at the upstream members to provide protection to regular lines of members in the direction of flow. Where such arrangements are made as a feature of the design, the total force calculated may be reduced, in the case of the shielded members, by up to 20 %.

8.2.5.2 Debris effect

The accumulation of debris is expected to produce a load on the structure that may be calculated as for that on a rectangular cofferdam. This load, F_w, in Newtons, shall be calculated from Equation (6):

$$F_w = 666 \times A \times v_w^2 \tag{6}$$

where

A is the area of obstruction presented by the trapped debris and falsework, in square metres;

v_w is the speed of water flow, in metres per second.

NOTE 1 If there is a possibility of logs or rubbish being washed or floating down after heavy rain, then an estimate of the possible loads should be made. It is normally preferable to prevent debris accumulating against the structure.

NOTE 2 Where a structure is subject to waves, account should be taken of the loads that may be imposed by the waves.

8.2.6 Seismic effects "Q_7"

Allowance should be made for seismic effects. Reference shall be made to EN 1998.

NOTE Attention is drawn to the provisions of national regulations concerning seismic effects.

8.3 Indirect actions

8.3.1 Temperature "$Q_{8,1}$"

Where the supported structure is longer than 60 m, the effects of temperature-induced movement of the structure on the falsework shall be taken into account for the following differences:

- supported structures of steel: ± 20 K;
- supported structures of concrete: ± 10 K.

8.3.2 Settlement "$Q_{8,2}$"

For class B1 the effects of differential settlement shall be taken into account in all cases.

For class B2 the effects of differential settlement shall be taken into account except in the following cases:

a) tube and fitting or timber falsework where the differential settlement, δ_s, is expected to be less than 10 mm;

b) prefabricated equipment where the differential settlement, δ_s, is expected to be less than 5 mm.

8.3.3 Prestressing "$Q_{8,3}$"

The effects of prestressing the permanent structure while supported on the falsework shall be taken into account.

8.4 Other actions "Q_9"

Values shall be established for all other identifiable loads.

8.5 Load combinations

Normally the following load combinations shall be taken into account (see Note 1):

- load case 1: unloaded falsework, e. g. before pouring;
- load case 2: falsework during loading, e. g. pouring;
- load case 3: loaded falsework;
- load case 4: loaded falsework subjected to seismic effects.

The load combination factors, ψ, specified in Table 1 shall be applied in conjunction with the actions specified in 8.1 to 8.3.

NOTE 1 If different conditions occur at site, it may be necessary to modify these combinations or take account of others.

NOTE 2 Figure 3 indicates typical loading conditions on falsework for in-situ concrete.

NOTE 3 There is a minimum load allowance for access on all areas which it is possible for people to reach. This is additional to the dead-weight of the concrete and the in-situ concreting allowance.

Table 1 — Load combination factors ψ

Action	Type of action	Combination factors ψ			
		Load case 1	Load case 2	Load case 3	Load case 4 [a]
	Direct actions				
Q_1	Permanent actions	1,0	1,0	1,0	1,0
Q_2	Variable persistent vertical imposed actions	0	1,0	1,0	1,0
Q_3	Variable persistent horizontal imposed actions	0	1,0	1.0	0
Q_4	Variable transient imposed actions	0	1,0	0	0
Q_5	Maximum Wind	1.0	0	1,0	0
	Working Wind	0	1,0	0	0
Q_6	Flowing water actions	0,7	0,7	0,7	0,7
Q_7	Seismic effects	0	0	0	1,0
	Indirect actions				
$Q_{8,i}$	Temperature	0	1,0	1,0	1,0
	Settlements		0	1,0	1,0
	Prestressing		0	1,0	1,0
Q_9	Other loading conditions	0	1,0	1,0	1,0

[a] This load case is a non-collapse requirement in accordance with EN 1998-1-1.

9 Structural design for classes B1 and B2

9.1 Technical documentation

9.1.1 Written information about the calculation

The structural design shall include:

a) the design class;

b) a description of the concepts adopted and of how the falsework is to be used, together with an explanation of the distribution of loads through the structure to the ground;

c) the sequence of operations, e.g.:

1) erection;

2) striking;

3) dismantling;

4) concreting sequence;

5) rate of pour;

d) a description of the model adopted for structural analysis, with a note of all assumptions made;

e) a list of all documents referred to in the calculations;

f) a specification for materials and components;

g) a key plan to identify the components of the falsework scheme and to relate them to the calculation and the as built falsework.

9.1.2 Drawings

9.1.2.1 Class B1

Drawings fully detailed to the standard of permanent works construction shall be provided.

9.1.2.2 Class B2

Drawings shall describe the falsework in plan, elevation and using sections where appropriate.

The drawings shall show at least:

a) typical details of construction;

b) all dimensions and materials;

c) all anchoring points required;

d) information on precambering;

e) information on the sequence of loading;

f) particular local requirements for special purposes, such as access for vehicles and all necessary clearances;

g) foundation details.

9.1.3 Information for the site

At least the following information shall be made available to the site:

a) method statement containing the information in 9.1.2.2 c);

b) drawings (see 9.1.2);

c) information about the use of any special equipment;

d) particular requirements about previously used materials;

NOTE This may be on drawings or as written information.

e) areas to be marked out which are specifically allocated to storage.

9.2 Structural design

9.2.1 General

The structural design shall be such that the structure is in accordance with the performance requirements in the following respects:

a) ultimate limit state (ULS): including loadbearing capacity, stability against sliding laterally, overturning and uplift;

b) serviceability limit state (SLS): deflection of the falsework consistent with the requirements for precambering.

NOTE Normally this is done by calculation, but it can be necessary to make tests for resistances and stiffnesses.

9.2.2 Extent of static calculation

9.2.2.1 Ultimate limit state

a) It shall be verified that:

$$E_d \leq R_d \tag{7}$$

where

E_d is the design value of an internal force or moment;

R_d is the corresponding design value of resistance.

The value of E_d shall be established from the design values of the actions Q_d, taking the second order effects into account where appropriate (for class B2 see 9.3.4.1).

b) Based on the characteristic value of the action $Q_{k,i}$ specified in Clause 8, the design value of the action Q_d shall be calculated using Equation (8):

$$Q_{d,i} = \gamma_{F,i} \times \psi_i \times Q_{k,i} \tag{8}$$

where

$Q_{d,i}$ is the design value of the action i;

$Q_{k,i}$ is the characteristic value of the action i;

$\gamma_{F,i}$ is the partial factor, to be taken as:

— 1,35 for permanent actions Q_1;

— 1,50 for all other actions (Q_2 / Q_9);

ψ_i is the load combination factor for action "i" (see Table 1).

c) Based on the characteristic values of the actions specified in Clause 8, the design values of the actions $Q_{d,i}$ for load case 4 (seismic) shall be calculated using Equation (8), taking $\gamma_{F,i}$ as 1,0.

d) The design value of the resistance $R_{d,i}$, for each of the classes B1 and B2, shall be calculated using Equation (9) or Equation (10) as appropriate:

1) for class B1:

$$R_{d,i,1} = \frac{R_{k,i}}{\gamma_{M,i}} \tag{9}$$

2) for class B2:

$$R_{d,i,2} = \frac{R_{k,i}}{\gamma_{M,i} \times 1{,}15} \tag{10}$$

where

$R_{k,i}$ is the characteristic value of the resistance for material "i";

$\gamma_{M,i}$ are the partial factors for material "i" (see 9.5.1).

9.2.2.2 Serviceability limit state

Provision will have to be made in setting the level of the falsework to allow for deformation so that the permanent structure will be of the required shape and size.

At least the following aspects shall be investigated:

— settlement of foundations;

— elastic shortening and joint take-up;

— deflection of beams.

For the serviceability limit state, the partial factors for actions and materials, γ_F and γ_M, shall be taken as 1,0.

9.2.2.3 Static equilibrium

9.2.2.3.1 General

The structure shall be stable under the load combinations specified in 8.5 in respect of sliding, overturning and uplift. For the purposes of determining whether a structure is stable, it shall be considered as a rigid body. Each action shall be considered individually to determine whether it is stabilizing or destabilizing. Values for the partial factor, $\gamma_{F,\,i}$, are given in Table 2.

NOTE The weight of kentledge may be considered as a permanent action, Q_1.

Table 2 — Partial load factors $\gamma_{F,i}$ for static equilibrium

Action	Stabilizing	Destabilizing
Q_1 and Q_2 in accordance with 8.2.2.1.1	0,9	1,35
All other actions	0	1,5

9.2.2.3.2 Global sliding

Global sliding shall be resisted either by means of friction resulting from self-weight or by a mechanical device or by a combination of both. Only where it can be shown that a mechanical device acts cumulatively with frictional resistance the resistances of both means of restraint may be taken into account simultaneously.

It shall be verified that the design force resisting sliding, $F_{stb,d}$, is greater than or equal to the design forces leading to sliding, $F_{dst,d}$ (see Table 2):

$$F_{dst,d} \leq F_{stb,d} \quad (11)$$

NOTE In cases where the flexibility of the bottom of the structure does not prevent independent movement of an individual leg, internal forces will be created and should be analysed accordingly; see 9.2.2.4.

9.2.2.3.3 Overturning

Overturning shall be resisted by self-weight, kentledge, a mechanical fixing or a combination of these.

It shall be verified that the design moment resisting overturning, $M_{stb,d}$, is greater than or equal to the design moment causing overturning, $M_{dst,d}$ (see Table 2):

$$M_{dst,d} \leq M_{stb,d} \quad (12)$$

NOTE Overturning can cause high local actions on the foundations that should be taken into account in their design.

9.2.2.3.4 Uplift

Uplift shall be resisted by self-weight, kentledge, a mechanical fixing or a combination of these.

It shall be verified that the design resistance against uplift, $N_{stb,d}$, is greater than or equal to the design forces causing uplift, $N_{dst,d}$ (see Table 2):

$$N_{dst,d} \leq N_{stb,d} \quad (13)$$

9.2.2.4 Local sliding

Local sliding shall be resisted either by means of friction or by a mechanical device or by a combination of both. Only where it can be shown that a mechanical device acts cumulatively with frictional resistance the resistances of both means of restraint may be taken into account simultaneously.

The stiffness of the mechanical device and any clearances or loosenesses that it needs to take up before generating resistance shall be taken into account.

It shall be verified that:

$$F_{d} \leq R_{f,d} \quad (14)$$

where:

$R_{f,d}$ is the design value of the resistance against sliding parallel to the plane of bearing (see Figure 4) and is calculated using Equation (15):

$$R_{f,d} = \frac{\mu}{\gamma_\mu} \times N_d + R_{m,d,i} \tag{15}$$

where

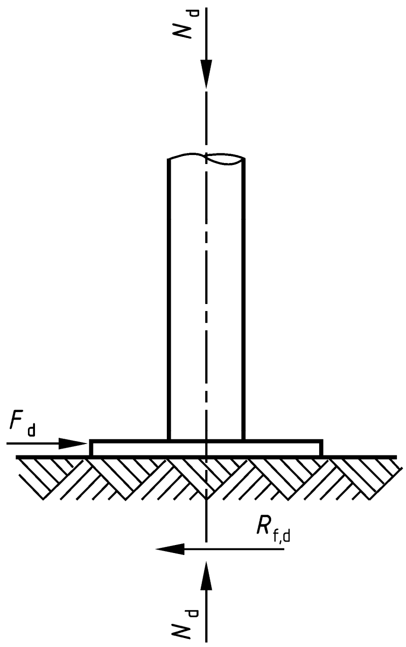
F_d is the design value of the force parallel to the plane of bearing leading to sliding (see Figure 4).

N_d is the design force normal to the plane of sliding (see Figure 4);

$R_{m,d,i}$ is the design value of the resistance of the mechanical device;

γ_μ is the partial factor for friction and is taken as 1,3;

μ is the minimum friction coefficient (see Annex B);



NOTE See 9.2.2.4 for symbol definitions.

Figure 4— Frictional resistance against local sliding

9.3 Imperfections and boundary conditions

9.3.1 General

The influence of imperfections such as the following shall be taken into account:

— eccentricities of loads;

— angular imperfections and eccentricities caused by looseness of the joints;

— divergence from the theoretical axes (bow imperfections, sway imperfections).

9.3.2 Angular imperfections and eccentricities at the spigot joints

9.3.2.1 Single tubes

For single tubes, angular imperfections, φ_0, from the theoretical position shall be calculated for loose items from the nominal dimensions of the components. Examples are spigot joints and base-jacks to tube connections.

The angular imperfection, φ_0, between two components shall be calculated using Equation (16):

$$\tan \varphi_0 = 1{,}25\,(d_i - d_0)/l_0 \qquad (16)$$

where

d_i is the nominal inner diameter of the tube;

d_0 is the nominal outer diameter of the spigot or jack spindle;

l_0 is the overlap length;

φ_0 is the angle, in radians, between the two components or loose items [see Figure 5a)].

If there is more than one upright in a row, the angle, φ, at a joint to be used for calculation purposes shall be calculated using Equation (17):

$$\tan \varphi = \sqrt{0{,}5 + \frac{1}{n_v}} \times \tan \varphi_0 \qquad (17)$$

where

n_v is the total number of vertical tubes to be erected side by side.

9.3.2.2 Frame components and other prefabricated members

For frame components and other prefabricated members assembled with spigot joints, the eccentricity, e, between two successive tubular vertical frames shall be taken into account. For a pair of frames assembled one above another, the eccentricity, e, shall be taken as at least that given by Equation (18):

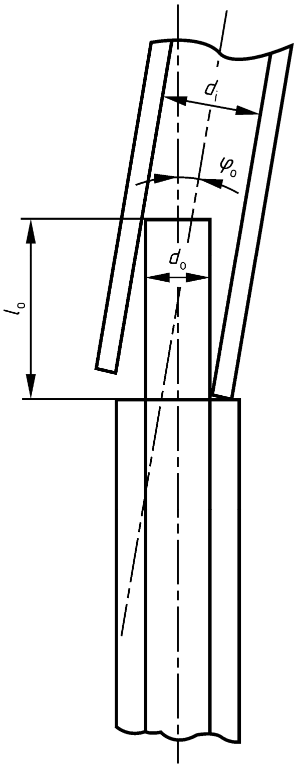
$$e = 1{,}25\,\frac{(d_i - d_0)}{2} \qquad (18)$$

where

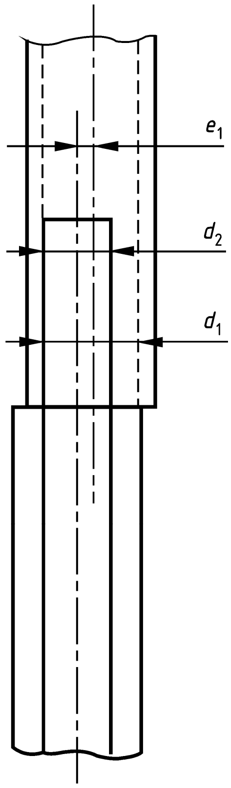
d_i and d_0 are defined in 9.3.2.1, and

e is the distance between the axes of two tubular members meeting end to end and all are as shown in Figure 5b).

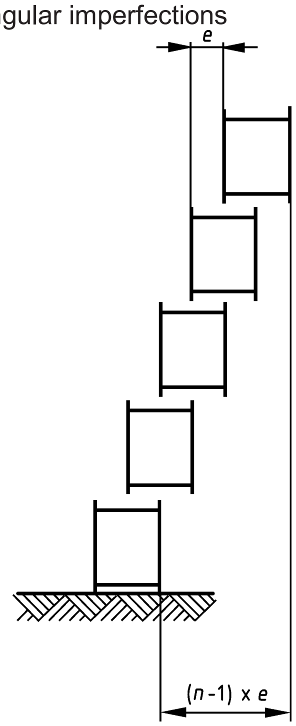
The accumulated eccentricity of an assembly of frames shall be taken into account in the structural design. Where all frames are offset in one direction, as in Figure 5c), this offset shall be taken as $(n - 1) \times e$, where n is the number of frames placed one above another. Where the top is restrained directly above the base, the central offset shall be taken as $(n-1)/2 \times e$. This is shown in Figure 5d).



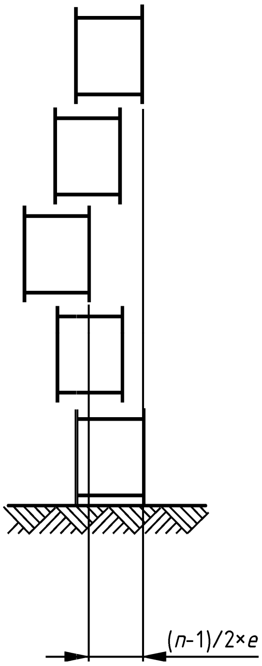
a) Spigot angular imperfections



b) Spigot eccentricities



c) Offsets resulting in a sway imperfection



d) Offsets resulting in a bow imperfection

NOTE See 9.3.2.1 and 9.3.2.2 for symbol definitions.

Figure 5 — Examples for calculation of imperfections of joints

9.3.3 Deviation from the theoretical axis for design: Class B1

Values for bow and sway imperfections for steel components and steel constructions are given in EN 1993-1-1.The angular imperfections and eccentricities described in 9.3.2 shall be used unless the actual values are obtained by measurement on site. The angular imperfections and eccentricities used in the design shall not be less than those in EN 1993-1-1.

9.3.4 Deviation from the theoretical axis for design: Class B2

9.3.4.1 Bow imperfections for compression members

Compression members shall be assumed to have an initial overall bow imperfection. Stabilising systems for compression members shall be designed to resist the effect of any bow. This is additional to the member imperfection of a single element, which is defined in EN 1993-1-1. Figure 6 illustrates the overall bow imperfections for a compression member.

The value to be assumed for the lateral displacement or deviation from a true line, e, in millimetres, for a compression member subjected to bending shall be calculated using Equation (19):

$$e = \frac{l}{250} \times r \qquad (19)$$

where:

l is the nominal length of the compression member in millimetres;

r is the reduction factor and is given by Equation (20):

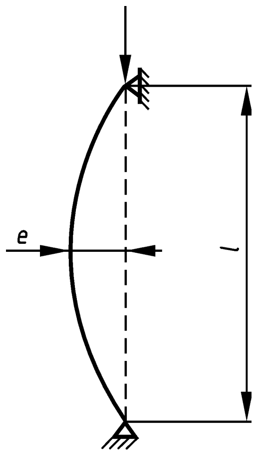
$$r = \sqrt{0,5 + \frac{1}{n_v}} \leq 1,0 \qquad (20)$$

where:

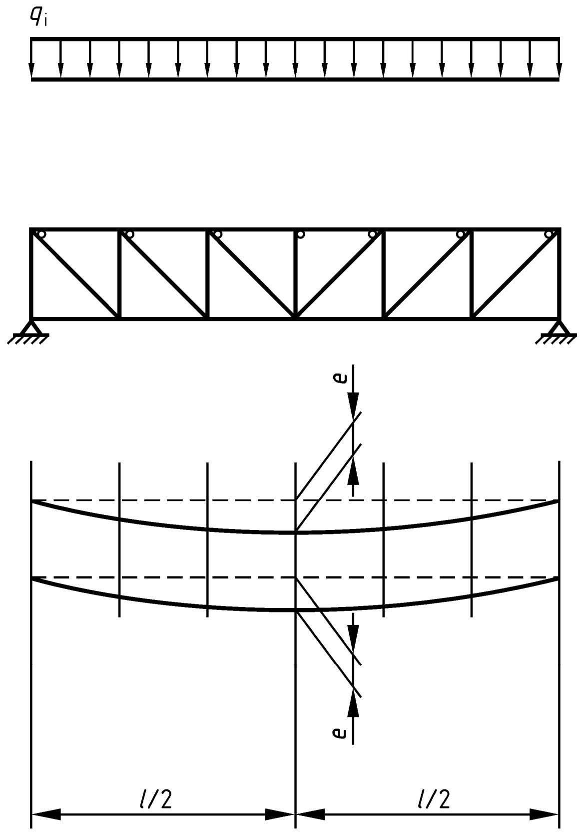
n_v is the number of structural components arranged and supported side by side and propped in the same way.

NOTE No account needs to be taken of the positions of joints.

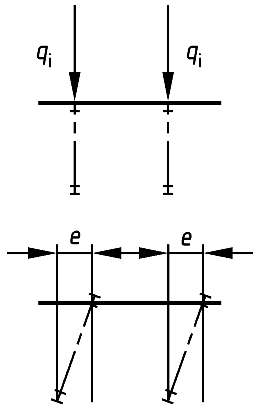
Alternatively deviations from the theoretical axis may be validated for design purposes by measurement. The bow imperfections used in the design shall not be less than those in EN 1993-1-1.



a) Elevation of a propped column



b) Elevation and plan of a simply supported truss



c) Section through two trusses

q_i is the representation of a notional uniformly distributed load in the plane of the beam.

NOTE See 9.3.4.1 for symbol definitions.

Figure 6 — Bow imperfections

9.3.4.2 Sway imperfections for compression members

The sway imperfection, φ, for a structural component taller than 10 m shall be calculated using Equation (21):

$$\tan \varphi = 0{,}01 \cdot \sqrt{\frac{10}{h}} \tag{21}$$

where

h is the overall height, in metres, of a compressive member or tower;

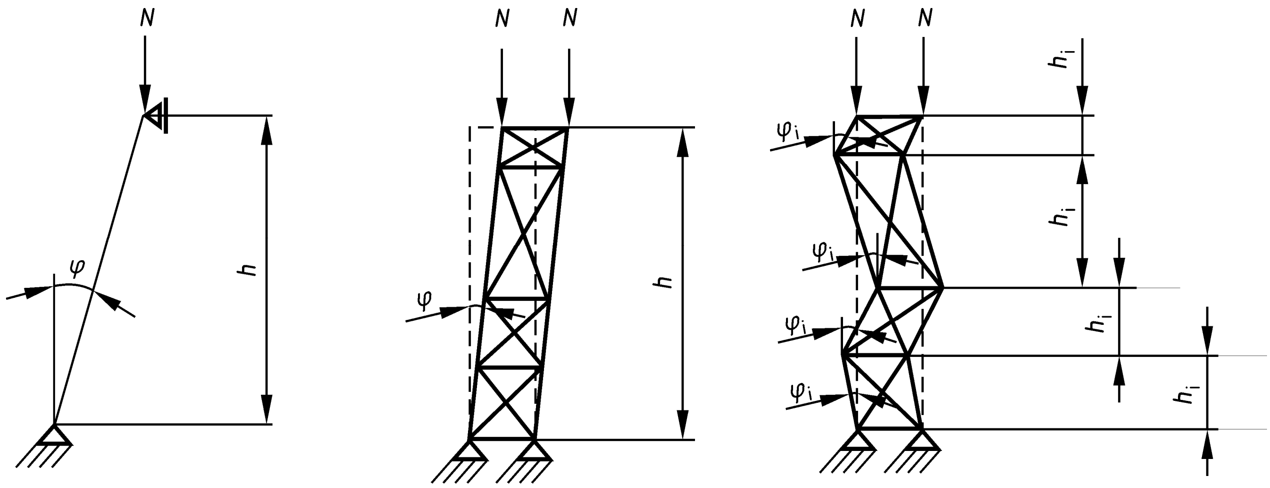
φ is the angular deviation from the theoretical line.

For structures where h is less than 10 m, tan φ shall be taken as 0,01.

The sway imperfection, φ, shall normally be taken as an overall imperfection, as shown in Figure 7a) and Figure 7b) for a single element and a lattice tower respectively. However where the compression elements are not continuous members, the sway imperfection for each individual component, of the type shown in Figure 7c) of height h_i, shall also be taken into account.

The overall sway imperfection and the sway for individual components need not be considered as simultaneous effects. The angular imperfection, φ, in Figure 7c) is defined in 9.3.2.1.

Alternatively the deviation from the theoretical axis may be defined for design purposes if these values will be verified on site.



a) Single member b) Modular overall tower c) Modular independent tower

h_i is the vertical distance between successive horizontal members one above the other.

N is a vertical load.

NOTE See 9.3.2.1 and 9.3.4.2 for other symbol definitions

Figure 7 — Sway imperfection of compression members

9.3.5 Base jacks

There are no specific requirements for base jacks within the remit of this standard. Requirements for the stiffness, ultimate bending resistance and point of support of base jacks with a diameter of 38 mm and a rigid connected endplate are given in EN 12811-1:2003, 10.2.3.2.

9.3.6 Eccentricity of load

The load eccentricity at load points shall be taken as a minimum of 5 mm where there is no centring device. Where there is a centring device the eccentricity taken may be reduced to a value consistent with the tolerances of the relevant components.

9.4 Calculation of internal forces

9.4.1 Design class B1

The internal forces shall be calculated in accordance with relevant European or International Standards for structural engineering.

9.4.2 Design class B2

9.4.2.1 General

Calculations shall be carried out using appropriate design models.

NOTE The models adopted should be sufficiently precise to predict the structural behaviour in relation to the level of workmanship expected to be achieved and to the reliability of the information on which the design is based. If a three-dimensional structural system is not used, the model may comprise more than one planar system, provided account is taken of the interaction.

In calculating the internal forces, some simplifications may be accepted, as indicated in the following sub-clauses. Elastic methods shall be used in determining the distribution of forces and displacements.

9.4.2.2 Load distribution

When calculating the internal forces, the actions may be calculated by dividing the structural model into statically determinate substructures. For example, parallel plane frames may be analysed independently. Care should be taken that the conditions at the boundaries between substructures are realistically modelled.

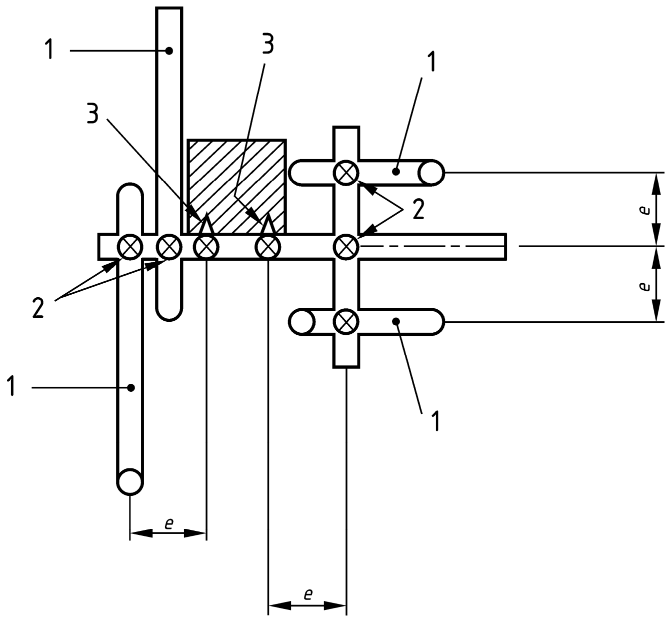
9.4.2.3 Design requirements

9.4.2.3.1 Eccentricities of tube and couplers

For 48,3 mm diameter tube and a wall thickness of min 3,2 mm, a single node point may be assumed if the centre lines of the load paths of all couplers are within a distance, e, of the node point adopted in the structural model.

This model shall be used only if the value of e, the eccentricity adopted at a node point, is not greater than 160 mm (see Figure 8). For tubes made of steel the following are the maximum axial forces in the diagonals in Figure 11 per node point.

Transom material $f_{y,k}$ = 355 N/mm^2: N_d = 13,5 kN
Transom material $f_{y,k}$ = 235 N/mm^2: N_d = 9,0 kN
$f_{y,k}$ is the yield stress of the material.



Key

1 diagonal tubes

2 coupler

3 single coupler fixing to the column

e see 9.4.2.3.1 for definition

Figure 8 — Maximum eccentricities for 48,3 mm steel scaffold tube

9.4.2.3.2 Bracing of truss beams

a) Buckling of compression members

Bracing members shall be attached to the compression member to provide restraint against lateral buckling.

b) Tube and coupler bracing of truss beams

Horizontal bracing designed to prevent buckling of compression members of truss beams and for the transfer of the forces at right angles to the load-bearing plane shall, where practicable, be attached directly to the compression member. Connection eccentricities, e, may be ignored during the design provided that all of the following conditions are met simultaneously (see Figure 9).

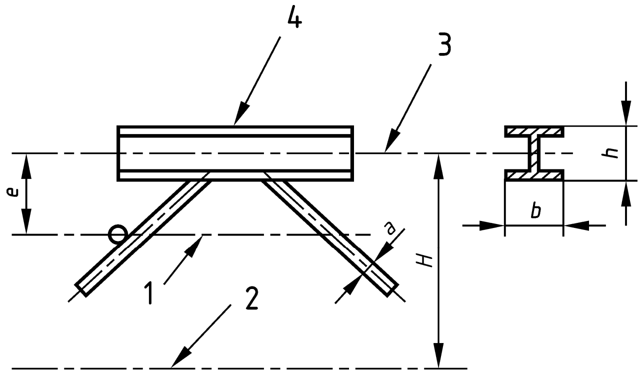
$e \leq 1{,}5\ b$	$e \leq 5{,}0\ a$
$e \leq 1{,}5\ h$	$e \leq 0{,}2\ H$

where:

- b is the width of the compression member;
- a is the smallest cross-sectional dimension of the truss beam bracing member;
- h is the vertical dimension of the cross section of the compression member;
- H is the distance between the centroidal axes of the compression member and of the tension member.

To ensure lateral stability when the beam is supported on the bottom member, either transverse bracing shall be provided at both ends (see example in Figure 10) or equivalent precautionary measures shall be taken.

The spacing between transverse bracing points shall not exceed 10 m.



Key

1 stiffening plane (horizontal bracing)

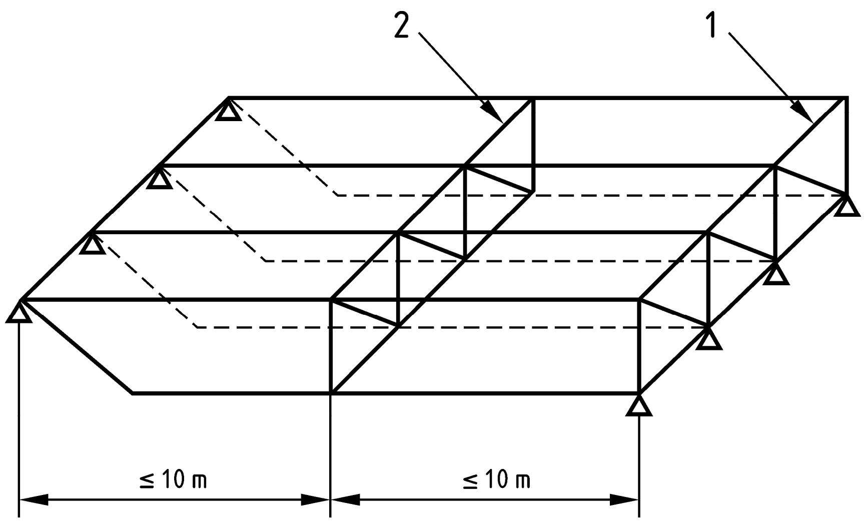
2 axis of bottom member

3 plane to be stiffened

4 top member

See 9.4.2.3.2 for symbol definitions

Figure 9 — Eccentricities at the connection of horizontal bracing to a truss beam



Key

1 end transverse bracing
2 intermediate transverse bracing

Figure 10 — Arrangement of transverse bracing

9.4.2.4 Shear stiffness

9.4.2.4.1 Ideal shear stiffness of bracing with tubes and fittings

Where a structure is braced with 48,3 mm diameter steel tube and right angle or swivel couplers in accordance with EN 74-1 and the joint eccentricities are within the limits set in 9.4.2.3.1, the ideal shear stiffness for each level, S_{id} (see Figure 11), shall be calculated using Equation (22):

$$S_{id} = \frac{E}{\beta} \sum_{n=1}^{m} A_n \times \sin^2 \alpha_n \times \cos \alpha_n \qquad (22)$$

where:

E is the modulus of elasticity of the diagonal tubes;

m is the number of diagonal members in each level (see Figure 12);

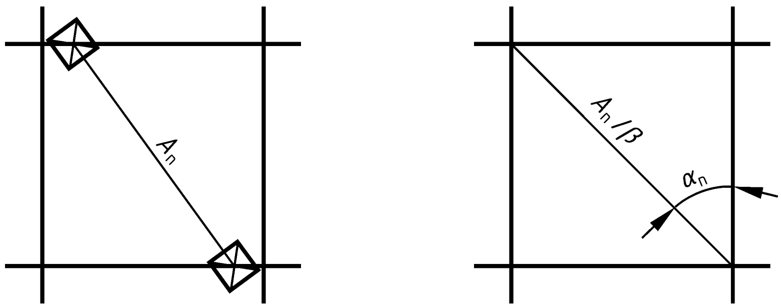
A_n is the area of any diagonal in the level (see Figure 11);

α_n is any angle from the vertical to the theoretical diagonals in the level (see Figure 11);

NOTE α_n may vary from level to level;

β is a reduction factor taking the eccentricities and stiffness of the coupler into account and is given by Equation (23):

$$\beta = \frac{35 \times (1 + m)}{2 \times m} \qquad (23)$$



a) Actual diagonal b) Theoretical diagonal

NOTE See 9.4.2.4.1 for symbol definitions.

Figure 11 — Relation between an actual and theoretical diagonal

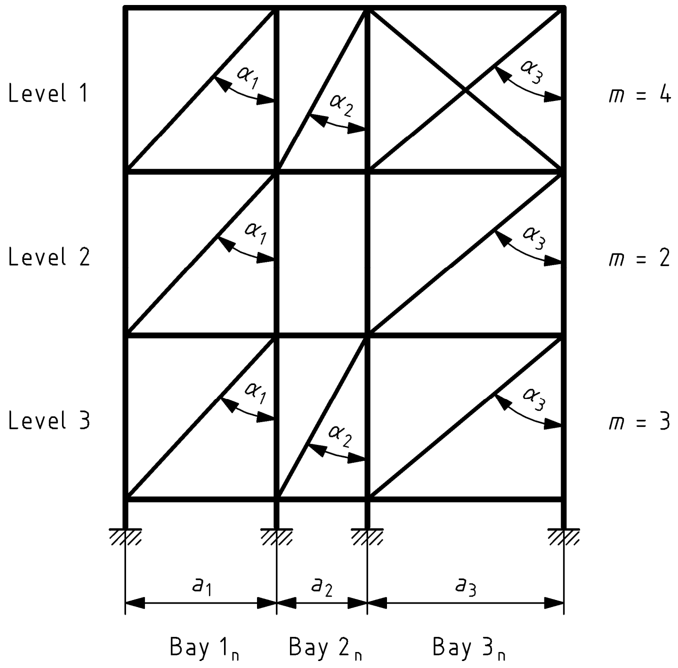


Figure 12 — Explanation of symbols for calculating the ideal shear stiffness of tube and fitting bracing systems

9.4.2.4.2 Ideal shear stiffness of timber bracing

Where there is a line of timber members which has braces attached by pins or dowels of any type, and the eccentricity, e, at a node point does not exceed 250 mm, the ideal shear stiffness of the level, S_{id} shall be calculated using Equation (24):

$$S_{id} = \sum_{n=1}^{m} \frac{l_n \times \sin\alpha_n \times \cos\alpha_n}{2 \times \left[\left(\frac{1}{n_{D,n} \times C_{VD,n}} \right) + \left(\frac{\sin^2 \alpha_n}{n_{R,n} \times C_{VR,n}} \right) \right]} \tag{24}$$

where:

l_n is the horizontal distance between a pair of vertical members in each bay in millimetres;

$C_{VD,n}$ and $C_{VR,n}$ are displacement moduli given in Table 3, based on connection type and size, in Newtons per millimetre;

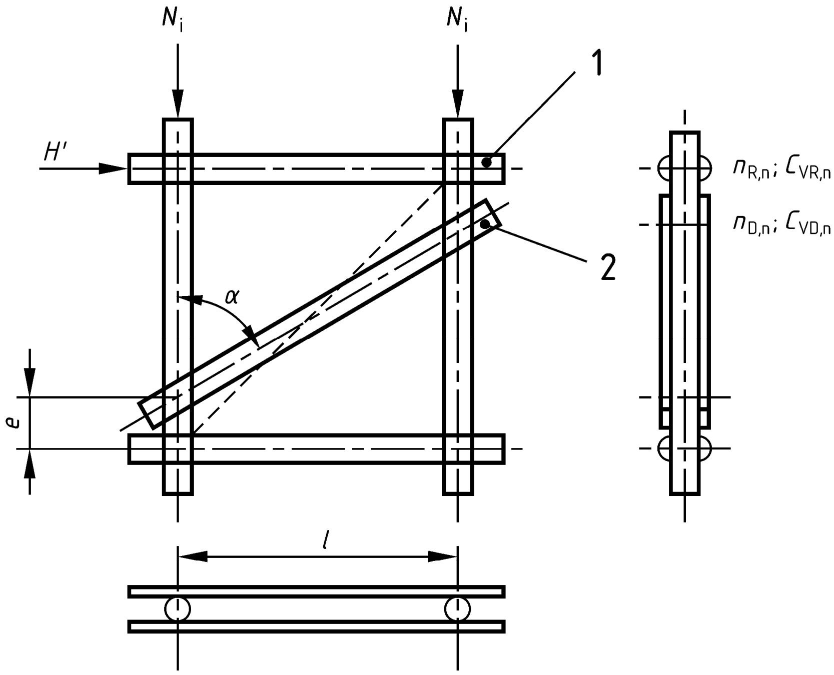
$n_{D,n}$ is the number of connectors of any diagonal at one node in each bay;

$n_{R,n}$ is the number of connectors of any transom in one node in each bay;

m is the number of braced panels in each level;

α_n is any angle from the vertical to the theoretical diagonals in the bay.

NOTE See Figure 13 for explanation of symbols in a single timber panel.



a) View b) Section

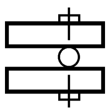
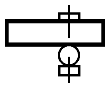
Key

1 transom

2 diagonal

Figure 13 — Explanation of symbols for calculation of timber frames

Table 3 – Displacement moduli C_{VD} or C_{VR} for timber connectors

Type of connector	**Pin** N/mm	**Dowel** N/mm
	25d^2	34d^2
	11d^2	15d^2
d is the diameter of the pin or dowel, in millimetres.		

9.4.2.4.3 Ideal shear stiffness of vertical members braced with tensioned rods

The ideal shear stiffness of a line of vertical members, braced with rods in tension, shall be calculated in accordance with 9.4.2.4.1 but with β equal to 2,0.

9.4.2.5 Forces and moments

9.4.2.5.1 Stiffening of free-standing lattice towers

The bracing for free-standing lattice towers may be calculated with the aid of the transverse force H_d" of a theoretical beam as an approximation. Buckling of all compression members shall be verified taking the distance between node points as the effective buckling length; see Figure 12.

The horizontal transverse design force on the tower, H_d", based on second order theory, shall be calculated using Equation (25):

$$H_d" = \frac{H_d + N_d \cdot \tan\varphi}{1 - (N_d / N_{cr})} \tag{25}$$

where:

N_{cr} is the critical load of the tower which is given by Equation (26):

$$N_{cr} = \frac{1}{(1/S_{id}) + (1/N_E)} \tag{26}$$

where:

N_E is the elastic buckling load of the tower;

N_d is the design value of the sum of the compressive forces;

H_d' is the sum of the transverse design forces arising from external loading applied at the top of the braced section of the structure;

S_{id} is the ideal shear stiffness (Shear buckling load of the tower) (see 9.4.2.4);

φ is the sway imperfection (see 9.3.4.2).

The corresponding moment, M", shall be calculated using Equation (27):

$$M" = H_d" \times h \tag{27}$$

where

H_d" is the transverse force taking second order theory into account and is given by Equation (25);

h is the overall height;

M" is the bending moment taking second order theory into account.

9.4.2.5.2 Stiffening of truss beams

This method may be adopted where the sum of the ideal shear stiffnesses of all intermediate transverse bracing members, ΣS_{id}, is greater than 40 % of the sum of the vertical forces on the beam. The relevant bracing is shown in Figure 10. This may be expressed as:

$$\Sigma S_{id} > 0,4 \times V_d \tag{28}$$

where:

V_d is the sum of all the vertical design loads on the group of trusses;

S_{id} is the ideal shear stiffness of the horizontal bracing between the truss beams.

The theoretical design force, H'', shall be calculated using Equation (29):

$$H_d'' = \frac{H_d' + 5 \cdot N_d \cdot \frac{e}{l}}{1 - (N_d / N_{cr})} \tag{29}$$

where:

l is the distance between the supports;

e is the bow imperfection in accordance with 9.3.4.1;

N is the sum of the maximum compressive forces in the top flanges of the group of trusses;

N_{cr} is the critical load and is given by Equation (26).

The corresponding bending moment in the horizontal plane at mid span, M'', shall be calculated using Equation (30):

$$M'' = H'' \times \frac{l}{\pi} \tag{30}$$

9.5 Characteristic values of resistance and friction values

9.5.1 General

For a calculation of the design value of the resistance of the steel or aluminium component, the partial factor, γ_M, shall be taken as 1,1, except where noted otherwise.

9.5.2 Characteristic values by test

If there is inadequate information about the characteristic value of the material or component under consideration, the values shall be established by testing in accordance with the appropriate European, international or national standard. Where tests are made, the provisions of EN 12811-3 shall be taken into account.

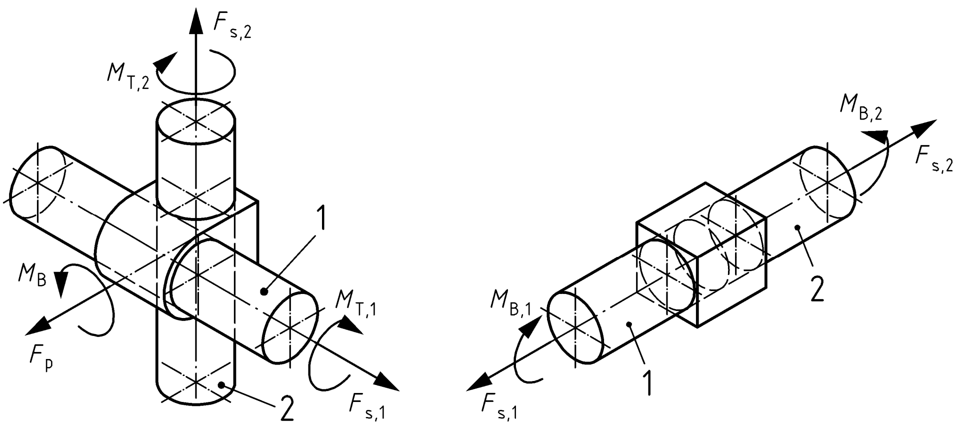
9.5.3 Couplers conforming to EN 74-1

The characteristic values for couplers conforming to EN 74-1 are given in Table 4.

Table 4 — Characteristic resistance values for couplers, $R_{s,k}$

Coupler type	Resistance	Characteristic value				
		class A	class B		class AA	class BB
Right-angle coupler (RA)	Slipping force $F_{s,k}$ in kN	10,0	15,0		15,0	25,0
	Cruciform bending moment $M_{B,k}$ in kNm	---	0,8		---	---
	Pull-apart force $F_{p,k}$ in kN	20,0	30,0		---	---
	Rotational moment $M_{T,k}$ in kNm	---	0,13		---	---
Friction type sleeve coupler (SF)	Slipping force $F_{s,k}$ in kN	6,0	9,0		---	---
	Bending moment $M_{B,k}$ in kNm	---	1,4		---	---
Swivel coupler (SW)	Slipping force $F_{s,k}$ in kN	10,0	15,0		---	---
Parallel coupler (PA)	Slipping force $F_{s,k}$ in kN	10,0	15,0		---	---

For symbols see Figures 14 a) and 14 b).



Key

1 tube 1
2 tube 2
s slipping force
p pull apart force
B cruciform bending moment
T rotational moment

a) – Loads on a right-angle coupler

Key

1 tube 1
2 tube 2
s slipping force
B bending moment

b) – Loads on a friction type sleeve coupler

Figure 14 — Symbols for characteristic slip resistance for couplers

9.5.4 Adjustable steel base and head jacks

Unless data is available from the standards referred to in 5.2.1, the characteristic values shall be established by calculation or testing.

9.5.5 Adjustable steel telescopic props

The characteristic values for props conforming to EN 1065 shall be in accordance with that standard.

9.5.6 Load-bearing towers

The characteristic resistance of a support tower within the scope of EN 12813 may be established by one of the methods specified in that standard.

9.5.7 Tension rods

The characteristic resistance of rods may be calculated from the characteristic yield stress of the material and the lesser of the rod thread area and the minimum rod cross-sectional area.

9.5.8 Tube with holes

The characteristic values shall be in accordance with EN 1065:1998, Annex A.

9.5.9 Girder clamps

The characteristic resistance shall be established by testing.

NOTE A girder clamp connects flanged structural steel members by means of friction.

9.5.10 Friction

Friction coefficients can be obtained from several different sources. Where friction coefficients are expressed as minimum and maximum values, the minimum coefficient shall be used if the frictional resistance is stabilising, and the maximum coefficient shall be used if the frictional resistance is destabilizing.

NOTE A set of friction coefficients is given in Annex B.

9.5.11 Foundations

The characteristic values for soils shall be established in accordance with the relevant standards.

9.5.12 Prefabricated timber formwork beams

The characteristic values for timber formwork beams conforming to EN 13377 shall be in accordance with that standard.

Annex A
(informative)

Relation with site activities

This European Standard is based on the assumptions given in the Eurocodes where the subject matter is relevant:

a) that the construction information, drawings, method statement and further necessary details, see 9.1.3, have been made available;

b) that site-related design assumptions are in conformity with the actual conditions;

c) that all works relevant to the falsework, e.g. formwork, falsework, sequence of concrete work, foundations and erection are effectively co-ordinated;

d) that the materials and components conform to the structural design specification [see 9.1.1f)];

e) that the erected falsework has been checked at all necessary stages and that it conforms to the design.

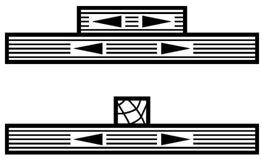
These activities should be coordinated.

Annex B
(informative)

Friction coefficients

Friction coefficients, μ, for various combinations of materials are given in Table B.1. The values given in Table B.1 are from research work in Germany.

Table B.1 — Friction coefficients, μ, for various combinations of materials

Building material combination		Friction coefficient μ	
		Maximum	**Minimum**
1	Wood/wood —  rubbing surface parallel to grain or at right angles to grain	1,0	0,4
2	Wood/wood — at least one rubbing surface at right angles to grain (cross-cut or end grain wood)  a)  b)	1,0	0,6
3	Wood/steel	1,2	0,5
4	Wood/concrete	1,0	0,8
5	Steel/steel	0,8	0,2
6	Steel/concrete	0,4	0,3
7	Steel/mortar bed	1,0	0,5
8	Concrete/concrete	1,0	0,5

Values for the characteristic coefficient of friction may be taken from other research work.

Bibliography

[1] EN 39, *Loose steel tubes for tube and coupler scaffolds - Technical delivery conditions*

[2] EN 1992 (all parts), *Eurocode 2 — Design of concrete structures*

[3] EN 1994 (all parts), *Eurocode 4 — Design of composite steel and concrete structures*

[4] EN 1995 (all parts), *Eurocode 5 — Design of timber structures*

[5] EN 1996 (all parts), *Eurocode 6 — Design of masonry structures*

[6] DIN 18218:1980, *Pressure of fresh concrete on vertical formwork*

[7] CIRIA Report No. 108, *Concrete pressure on formwork*, 1985

[8] *Manual de Technologie: Coffrage*; CIB-FIB-CEB 27-98-83.

National Annex (informative)
Guidance on the application of BS EN 12812:2008

NA.1 General

This national annex is intended to help those familiar with British practice to understand EN 12812:2008.

NA.2 NA Scope to EN 12812 (Clause 1)

EN 12812 provides requirements for the design of falsework, using the limit state design method, rather than the permissible stress method, which is commonly used in the UK.

The field of application given does not include provisions for access and working scaffolds. These are specified in BS EN 12811-1. Technical guidance on the use of BS EN 12811-1 for scaffolds with tube and fittings is given in the NASC document TG20.

NA.3 Terms and definitions: imperfections (3.7)

A sway imperfection is the out of true before loading in an erected structure, measured as an angle. It is a value for design purposes and may be more than the erection tolerance.

NA.4 Design classes (Clause 4)

EN 12812 describes three classes of falsework, Classes A, B1 and B2, which are distinguished by the methodology of design and/or physical parameters.

Class A has dimensional limitations, which will generally restrict its application to building work. As no specific structural design rules are given within this class, it is recommended that in the UK the design rules in BS 5975 be adopted for Class A falsework.

NOTE The structural performance of Class A falsework is determined from pre-existing knowledge of the performance of the components of the structure, such as adjustable steel props or proprietary falsework equipment. Such information is often included in standard solutions.

Class B1 is based directly on the Eurocodes series (EN 1990, EN 1991 to EN 1999), with the design process and all documentation being to the standard of permanent works design.

Subclause **4.3.1** contains requirements on Class B1 falsework but does not refer to the additional requirements for Class B1 falsework that are elsewhere in the document. It is assumed in the UK that the intention is for Class B1 falsework to conform fully to this standard, except for subclauses **9.3.4** and **9.4.2** which refer to the simplified method given for Class B2.

Class B2 is based on a lower level of calculation. It takes second order effects into account and contains some information on simplified methods. To compensate for the less stringent analysis, an additional factor of 1,15 [see equation (10)] is applied.

NOTE Although Clause **4.3** implies that Class B2 has the same level of safety as Class B1, the use of the simpler design method with the increased factor, will generally give a more conservative design, than that adopted using Class B1.

The national foreword makes reference to the procedural controls and permissible stress design contained in BS 5975.

NA.5 Weldability (5.3)

EN 12812:2004 contained the following Note to subclause **5.3** not included in the 2008 revision:

NOTE Different steels require different welding techniques. In general, welding of unidentified steels should not be undertaken for structural work. Steelwork that has been repaired by welding may be used provided that the remedial work has been carried out in accordance with the appropriate standard. The type and grade of steel should first be identified.

NA.6 Brief (Clause 6)

A more comprehensive list to be considered for inclusion in a design brief is provided in BS 5975. Attention is drawn to the requirements of the Construction (Design and Management) Regulations 2007, and the user obligations they contain. In particular, any assumptions or risks identified by the designer of the permanent works should be included in the design brief and communicated to the temporary works designer.

NA.7 Design requirements (Clause 7)

NA.7.1 Thickness of steel and aluminium components (7.2.1)

The nominal thickness of steel and aluminium sections, as specified in **7.2.1**, is not to be less than 2 mm. This limitation on thickness is to guard against the consequences of corrosion and site damage.

NA.7.2 Steel scaffold tubes (7.2.2)

The standard for scaffold tubes in the UK is BS EN 39.

NA.7.3 Flexibility of prefabricated support towers (7.4)

BS EN 12812:2004 contained the following Note to **7.4** not included in the 2008 revision:

NOTE This requirement for flexibility is intended to enable towers to be used in typical site conditions.

NA.7.4 Stacked squared members (7.5.4)

The designer should consider the stability of individual components and combinations of components.

NA.7.5 Towers providing support (7.6)

7.6 requires that the cross-sectional shape of the support structure shall be maintained at the top and bottom. At the base, stiffening will normally be provided by friction from whatever is below. What is supported above cannot necessarily be relied upon to provide a stiffened plane.

NA.8 Actions (Clause 8)

NA.8.1 Concrete pressure (8.2.3.2)

Some concrete mixes used may fall outside the documents stated in **8.2.3.2**. In these cases, specialist advice should be sought.

NA.8.2 Maximum Wind (8.2.4.1)

For falsework erected in the UK, it is recommended that, unless a specific sub-annual period can be guaranteed, the seasonal factor of unity (c_{season} = 1.00), and a minimum probability factor of c_{prob} = 0,83 should be used. This probability factor corresponds to a return period for the peak velocity of two years instead of the normal 50 year period.

NOTE The guidance on façade retention structures, CIRIA Report C579 recommends a value of c_{season} = 1,0 and c_{prob} = 1,00.

NA.8.3 Seismic effects (8.2.6)

8.2.6 draws attention to seismic forces with reference to EN 1998. The risk of seismic activity in the UK is low and consideration may normally be discounted.

NA.8.4 Temperature "$Q_{8,1}$" (8.3.1)

A degree Kelvin has the same incremental value as a degree centigrade.

NA.8.5 Prestressing (8.3.3)

No advice is given on prestressing effects, although it is mentioned briefly in **8.3.3**. Users may find it useful to seek specialist advice.

NA.8.6 Load combinations (8.5)

The recommended load combination factors in **8.5** and Table 1 should be used, except as noted:

The implication in Table 1 that settlement of falsework, $Q_{8,1}$, does not take place during loading, i.e. placing concrete, at Load Case 2 is not understood. The UK recommendation is that settlement may need to be considered in Load Case 2 and 3, but settlement is not relevant to Load Case 4.

Where friction can lead to unsafe internal forces, the maximum value should be chosen.

NA.9 Structural design for classes B1 and B2 (Clause 9)

NA.9.1 Global sliding (9.2.2.3.2) and local sliding (9.2.2.4)

EN 12812 gives three means of resisting sliding: self-weight, a mechanical device, or a combination (with caution). Note that BS 5975 advises against the combination option.

NA.9.2 Deviation from theoretical axis for design: Class B.1 (9.3.3)

In **9.3.3**, the reference to site measurements is assumed to include historic data.

NA.9.3 Eccentricities of tube and couplers (9.4.2.3.1)

The characteristic value of axial load in the diagonal tubes N_d may be limited by the capacity of the coupler used. See Table 4.

NA.9.4 Ideal shear stiffness of bracing with tube and fittings (9.4.2.4.1)

β, as used in **9.4.2.4.1**, was established by custom and practice.

NA.9.5 Ideal shear stiffness of timber bracing (9.4.2.4.2)

Pins are driven into holes; dowels are in close tolerance holes.

NA.9.6 Characteristic values of resistance and friction values (9.5, Table 4)

The characteristic slip resistance for parallel couplers as given in Table 4 is for a coupler connecting two parallel tubes together.

NA.10 Relation with site activities (Annex A)

UK practice regarding the coordination of site activities and procedural controls are given in BS 5975.

NA.11 Friction coefficients (Annex B)

A set of friction coefficients is given in Table B.1. More extensive data is available from research by the University of Birmingham, published in CONCRETE, June 2002 (see NA.12) and incorporated into Table 24 of BS 5975.

NA.12 National bibliography

Standards publications

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

BS EN 12811-1:2003, *Temporary works equipment — Part 1: Scaffolds — Performance requirements and general design*

BS EN 13670:2009, *Execution of concrete structures*

Other publications

PALLETT, P.F., GORST, N.J.S., CLARK, L.A., THOMAS, D.A.B. Friction Resistance in Temporary Works Materials. In: CONCRETE. Crowthorne: June 2002, Vol. 36, No.6, pp.12-15.

NATIONAL ACCESS & SCAFFOLDING CONFEDERATION, TG20 Technical Guidance to BS EN 12811-1 – Guide to Good Practice for Scaffolding with Tubes and Fittings, London, November 2008, Vol.1-120pp, Vol.2-128pp.

SG4:10 NATIONAL ACCESS & SCAFFOLDING CONFEDERATION, Preventing Falls in Scaffolding, SG4:10, November 2010, NASC, London, 60pp.

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™