

Code of practice for falsework

ICS 91.220

Committees responsible for this British Standard

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- Association of Building Component Manufacturers
- Association of Consulting Engineers
- British Constructional Steelwork Association Ltd.
- British Iron and Steel Producers Association
- Building Employers Confederation
- Concrete Society
- Construction Fixings Association
- Construction Health and Safety Group
- Construction Industry Training Board
- Convention of Scottish Local Authorities
- Federation of Civil Engineering Contractors
- Health and Safety Executive
- Institute of Building Control
- Institution of Civil Engineers
- Institution of Structural Engineers
- National Association of Scaffolding Manufacturers' Association
- Suspended Access Equipment Manufacturers' Association
- Co-opted members

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Foreword

This edition of BS 5975 (BS 5975:1996) was prepared by Technical Committee B/514 and supersedes BS 5975:1982, which has been withdrawn. It introduces technical changes but does not constitute a full revision of BS 5975:1982.

Amendment No. 2 has been occasioned by the publication of BS EN 12812:2004. Technical Committee B/514 intends to fully revise BS 5975:1996 to take account of changes in legislation and practice within the next two years.

BS 5975:1996 provides recommendations on the design of falsework using permissible stress methods and on procedures for the successful management of work on site, including the appointment of a falsework coordinator. These recommendations are re-affirmed by Technical Committee B/514.

BS EN 12812:2004 now exists in parallel with this standard and 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 EN 12812:2004 does not provide guidance on procedures necessary for the successful management of work on site. The recommendations of the Advisory Committee on Falsework (the “Bragg Report” [1] [2])¹⁾ in respect of the falsework coordinator have not been included in it.

The need for authoritative guidance on falsework has been growing with the increase in scale, frequency and complexity of its applications. Many organizations have arisen in the industry to provide specialist services, and a greater reliability of performance has been sought, preferably without a cost penalty. These factors have led to the publication of this code of practice. The need for such information was also illustrated by the “Bragg Report”. Prior to the preparation of this code, no previous code was known to exist anywhere in the world; during the drafting stages the main document drawn upon was thus the “Falsework Report” of the Joint Committee of the Institution of Structural Engineers and the Concrete Society [3].

This code has drawn together all those aspects that need to be considered when preparing a falsework design, and in so doing has included recommendations for materials, design and work on site. Because the success of falsework is closely tied up with its management, this code describes procedures as well as technical aspects. Recommendations are given in Section 2 on the actions that ought to be taken, and on possible ways of allocating the duties to individuals. The “Bragg Report” recommended that the duty of ensuring that all the relevant procedures and checks had been carried out be given to one individual in the construction organization, such an individual being known as the “Temporary Works Coordinator”. This code endorses such action but has adopted the narrower term “falsework coordinator”, because this code is concerned only with falsework and does not consider any of the other activities usually covered by the general term “temporary works”, such as excavations. A full description of the duties of the falsework coordinator will be found in Section 2.

This new edition of the code brings it into line with BS 5268-2. The original document published in 1982 anticipated many of the changes incorporated into BS 5268, but a number of minor differences have arisen, which are now corrected. This code adopted two special factors for shear and compression, to bring stresses into line with common acceptable falsework practice, and these are retained. Also retained are the strength classes of BS 5268, but with minor differences to the values.

¹⁾ The numbers in square brackets used throughout the text of this code relate to the bibliographic references in Annex N.

This code provides guidance on the accuracy of construction required in order to be able to adopt the recommended design approaches. While there is adequate information available upon which to base the recommendations for the deviations associated with the design parameters adopted for props [7, 8], in other areas the information is limited, consequently the committee would welcome any feedback on this point.

Users of this code are reminded that it may be necessary for them to appraise third parties with whom they are in contractual relations of certain provisions in the code.

Users of this code should be in possession of the Concrete Society document *Formwork — A guide to good practice* [12], the CIRIA Report No. 108 [4] and Concrete Society Technical Report No. 5 [11].

Forces exerted by breaking waves can be large and have to be considered during the design of any structure which may be subjected to such conditions. Until such time however, as methods of calculating forces exerted on vertical walls by breaking waves can be recommended with confidence such problems should be referred to an engineer experienced in the design and construction of structures subject to wave attack.

CP3: Chapter V-2 will be superseded on publication of BS 6399-2.

The implications of this different presentation are being examined and an appropriate amendment will follow in due course. It now provides information in accordance with BS 1139-1.1, BS 1139-2.1 and BS 1139-2.2. Because of the large amount of equipment still in use, it also retains information in accordance with the corresponding 1982 editions.

This standard does not introduce limit state design, however, a number of points relating to steel have been changed to bring it into line with current practice for steel, in particular BS 449-2, including all amendments.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 141 and a back cover.

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Section 1. General

1.1 Scope

This code of practice gives recommendations for the design and use of falsework on construction sites. The definition of falsework given in 1.3.9 is broad, but this code does not give information on the support of excavations (see BS 6031) nor does it describe flying shores or the like (see CP 2004). For guidance on the design and use of access scaffolding and special scaffold structures other than falsework, reference should be made to BS 5973.

A considerable amount of falsework is of comparatively low technology, and very repetitive. Section 8 provides information to deal with a limited number of such cases, described as “standard solutions” Guidance for producing comparable data for similar situations using, for example, particular items of proprietary equipment is also provided.

1.2 References

1.2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on pages 134, 135 and 136. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the publication referred to applies together with any amendments.

1.2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed in Annex N and on page 134, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this code, the following definitions, together with those given in Annex F, apply.

1.3.1 baseplate

A metal plate with a spigot for distributing the load from a standard, raker or other load-bearing member.

1.3.2 bay length

The distance between the centres of two adjacent standards measured horizontally.

1.3.3 blinding

A layer of lean concrete usually 50 mm to 100 mm thick, put down on soil such as clay to seal the ground and provide a clean bed for construction work.

1.3.4 brace

A tube placed diagonally with respect to the vertical or horizontal members of a scaffold and fixed to them to afford stability.

1.3.5 camber

The international curvature of a beam or formwork, either formed initially to compensate for subsequent deflection under load, or produced as a permanent effect for aesthetic reasons.

1.3.6 coupler

A component used to fix scaffold tubes together.

1.3.7 erection drawing

A drawing prepared prior to erection showing the arrangement and details of the falsework structure.

1.3.8 factor of safety

The ratio of ultimate load to the maximum working load.

1.3.9 falsework

Any temporary structure used to support a permanent structure while it is not self-supporting.

1.3.10 floor centre

A beam of adjustable length, usually a metal lattice or sheet metal box beam, used to support decking for a floor slab.

1.3.11 fork head

A U-shaped housing used to support joists or the like.

1.3.12 formwork and forms

The section of the temporary works used to give the required shape and support to poured concrete. It consists primarily of sheathing material (e.g. wood, plywood, metal sheet or plastic sheet) in direct contact with the concrete, and joists or stringers that directly support the sheathing.

1.3.13 foot tie

A member close to the ground, stabilizing two or more standards.

1.3.14 frame

The principal panel unit of a prefabricated falsework structure formed from welded, bolted or clamped tubular or rolled steel sections.

1.3.15 grade stress

The stress that can be safely sustained by timber of a particular strength class, or species and grade.

1.3.16 guard rail

A member incorporated in a structure to prevent the fall of a person from a platform or access way.

1.3.17 joint pin

An expanding fitting placed in the bore of a tube to connect one tube to another coaxially.

1.3.18 joist

A horizontal or sloping beam, e.g. the horizontal timbers that carry decking for a suspended concrete slab.

1.3.19 lacing

Essentially horizontal members that connect together and reduce the unsupported length of columns.

1.3.20 permissible stress

The stress that can be sustained with acceptable safety by a structural component under the particular condition of service or loading.

1.3.21 permit to load

A certificate issued to indicate that the falsework may safely be put to its designed use.

1.3.22 prop

A compression member used as a temporary support and incorporating a means for varying and fixing its length.

1.3.23 repropping

A system used during the construction operation in which the original props are removed and replaced in a sequence planned to avoid any damage to partially cured concrete.

1.3.24 scaffold

A temporarily provided structure that provides access, or on or from which persons work, or that is used to support material, plant or equipment.

1.3.25 sole plate (or sill)

A timber, concrete or metal spreader used to distribute the load from a standard or baseplate to the ground.

1.3.26 spigot pin

A pin placed transversely through the spigot and the scaffold tube or frame to prevent the two from coming apart.

1.3.27 standard

A vertical or near vertical tube.

1.3.28 stiff length (of the bearing)

The length of the bearing that cannot deform appreciably in bending.

1.3.29 strength class

A classification of timber based on particular values of grade stress.

1.3.30 strength ratio

The ratio of the grade stress to basic stress of timber.

1.3.31 strut

A member in compression.

1.3.32 toe board

An upstand at the edge of a platform intended to prevent materials or operatives' feet from slipping off the platform.

1.3.33 tower

A tall composite structure, used principally to carry vertical loading.

1.3.34 wedge

A piece of strong timber or metal that tapers in its length and is used to adjust elevation or line or to tighten falsework. Folding wedges comprise a pair of wedges laid one above the other so that their outer faces are parallel.

1.4 Symbols

For the purposes of this code, the following symbols, together with those in Annex F, apply. (See Note 1.)

Symbol (see Note 2)	Quantity	Unit of measurement (see Note 3)
A_d	area of obstruction presented by trapped debris and falsework	m^2
A_e	effective frontal area	m^2
A_w	effective area normal to flow	m^2
A_x	cross-sectional area of pipeline	mm^2
B	width of foundation	m
b	stiff length of the bearing	mm
c	undrained shear strength	N/m^2 , kN/m^2
C_f	force coefficient for wind	non-dimensional
C_o	Euler critical stress	N/mm^2
C_w	force coefficient for water	non-dimensional
D	overall depth of beam or section	mm
d	depth	m
d_f	clear distance between flanges	mm
E	Young's modulus of elasticity	N/mm^2 , kN/mm^2
e_o	eccentricity of beam bearing	mm

Symbol (see Note 2)	Quantity	Unit of measurement (see Note 3)
F_{bc}	maximum applied compressive bending stress	N/mm ²
F_c	maximum applied compressive axial stress	N/mm ²
F_d	force on trapped debris	N
F_f	limiting value of the frictional force	N
F_{Re}	see Annex K	N/mm ²
F_w	force due to flowing water	N
F_x	force due to concrete pipeline	N
H	height above ground level	m
h	depth below ground level	m
H_c	compression flange restraint force	N
h_F	windward height of falsework	m
h_f	windward height of formwork	m
J	moment of inertia of stiffener	mm ⁴
K_1	modification factor for timber (geometrical properties)	non-dimensional
K_2	modification factor for steel (from BS 449-2)	non-dimensional
K_3	modification factor for timber (duration of load)	non-dimensional
K_4	modification factor for timber (length of bearing)	non-dimensional
K_a	active pressure factor	non-dimensional
K_p	passive pressure factor	non-dimensional
L	overall length of span	mm
	length of stiffener	mm
	length of compression flange	mm
	length between the centre-to-centre of intersection with supporting members	mm
l	effective length	mm
L_b	clear length of a beam	mm
L_f	frontal length of soffit measured normal to the wind	m
L_s	clear length of a column or strut	mm
L_w	width between vertical forms	mm
m	factor for cantilever projection	non-dimensional
n	number of node points	non-dimensional
	number of edge forms	non-dimensional
	length obtained from stiff length of bearing, b	mm
P	force	N
p	maximum pressure in pipeline	N/mm ²
p_a	active soil pressure	N/m ²
P_B	force normal to a sloping soffit	N
p_b	allowable bearing stress	N/mm ²
p_{bc}	permissible bending stress in compressive members	N/mm ²
p_{bt}	permissible bending stress in tension members	N/mm ²
p_c	permissible axial compressive stress	N/mm ²
P_h	horizontal component of a force on a sloping formwork surface	N
P_L	force on a left hand formwork face	N

Symbol	Quantity	Unit of measurement
(see Note 2)		(see Note 3)
p_p	passive soil pressure	N/mm ²
P_R	force on a right hand formwork face	N
P_v	vertical component of a force on a sloping formwork surface	N
q	dynamic wind pressure	N/m ²
q_b	allowable bearing pressure	kN/m ²
q_w	dynamic pressure of flowing water	N/m ²
R	reaction force	N, kN
r	radius of gyration	mm
S_1	topography factor for wind	non-dimensional
S_2	ground surface conditions and height above ground factor for wind	non-dimensional
S_3	statistical (duration of exposure) factor for wind	non-dimensional
T	mean thickness of flange	mm
$T_{\max}$	maximum thickness of compression flange	mm
t_s	web stiffener thickness	mm
t_w	web thickness	mm
U	concrete tube strength	N/mm ²
V	basic wind speed	m/s
V_H	hourly mean wind speed at height H	m/s
V_s	design wind speed	m/s
V_w	speed of water flow	m/s
W	$\left\{ \begin{array}{l} \text{vertically applied force} \\ \text{total load on girder} \end{array} \right.$	$\left\{ \begin{array}{l} \text{N} \\ \text{kN} \end{array} \right.$
W_m	maximum wind force during life of falsework	N
W_w	maximum wind force during working operations	N
Y_s	minimum yield stress	N/mm ²
z	elastic modulus	cm ³
β	aerodynamic solidity ratio	non-dimensional
γ	soil density	kg/m ³
Δ_b	out-of-straightness of a beam	mm
Δ_s	out-of-straightness of a column or strut	mm
Δ_v	inclination from vertical	mm
η	shielding factor	non-dimensional
θ	angle from horizontal	degrees
μ	coefficient of static friction	non-dimensional
σ	factor for slenderness ratio	non-dimensional
φ	angle of internal friction	degrees
φ_w	geometric solidity ratio	non-dimensional

NOTE 1 The symbols given in the above list should not be confused with those given in Annex F, where some of the symbols represent different quantities.

NOTE 2 Unless included in the description of the quantity, symbols may have (further) subscripts 1, 2, etc.

NOTE 3

a) Where more than one unit of measurement is given, reference should be made to the relevant application.

b) 1 N/m² = 1 Pa. 1 N/mm² = 1 MN/m² = 1 MPa.

1.5 Legislation

The following legislation relates to falsework operations and compliance with this is always a statutory requirement:

Health and Safety at Work etc. Act 1974; Factories Act 1961;

Construction (General Provisions) Regulations 1961 (S.I. 1961, No. 1580);

Construction (Lifting Operations) Regulations 1961 (S.I. 1961, No. 1581);

Construction (Working Places) Regulations 1966 (S.I. 1966, No. 94);

Construction (Health and Welfare) Regulations 1966 (S.I. 1966, No. 95);

Construction (Design and Management) Regulations 1994 (S.I. 1994, No. 3140);

The Management of Health and Safety at Work Regulations 1992.

Section 2. Procedures

IMPORTANT NOTE This section discusses procedural aspects in general terms and it is not the intention of this section to limit the user of this code to any particular method of work. The details of procedures and responsibilities will be influenced by various factors, including the size of the scheme and/or of the organization(s) responsible, and the terms of any contract under which the work is being performed.

2.1 General

2.1.1 Introduction

Collection and application of technical data of the type set out in Section 3 to Section 8 represents only a part of the action necessary to ensure the preparation and execution of a safe and economical falsework scheme. Satisfactory technical solutions can only be assured when adequate control and communication are achieved during both the design and execution of a scheme, and before embarking upon new work every effort should be made to ensure that effective work procedures are developed and put into use. Experience has shown that the use of proper procedures leads to improvements in safety and economy in operation.

One of the main aims of any method of work should be to minimize the chance of errors being made and to maximize the chance of errors being discovered if they are made. To this end there needs to be effective communication of requirements between all levels of the construction organizations involved in a scheme, whether large or small, and whether they are concerned primarily with the permanent works or the temporary works. An effective system of checking is also needed (see 2.6).

2.1.2 Variety of falsework

The basic procedures to be applied in all falsework are the same, and only the scale of application differs. The recommendations of this code give guidance to those responsible for aspects of design, selection of materials, erection, checking, use, maintenance and dismantling of falsework. It may be possible in the simpler and more commonplace cases for standard solutions to replace individual designs. Some information on standard solutions is given in Section 8 but the standards required and the need for checking are in no way reduced in comparison with the larger, more complex, and specifically designed schemes.

2.1.3 Procedure when more than one organization is involved

While on many occasions the design and construction of permanent works and the attendant falsework will directly involve only one or two organizations, it is becoming increasingly common for the design and/or construction of a part or the whole of a falsework scheme to be undertaken by specialist subcontractors, so introducing further organizational interfaces. Common arrangements include the following and combinations thereof:

- a) equipment may be hired, with the supplier carrying out the design, or supplying the basic design data;
- b) equipment may be erected using operatives who are not direct employees of the main construction organization, e.g. the supplier of the equipment may also erect it;
- c) use of a design produced by another organization;
- d) the complete operation may be carried out by another organization.

NOTE More than one additional organization may be involved.

When work is being carried out by different organizations, the organizational interface may be manifested on site as physical interfaces between different phases of the scheme, e.g. it is common for one organization to prepare and provide the foundations upon which another subsequently erects the main falsework structure. The physical interface in this example is particularly critical, but in all cases it is important that the physical limits and interface conditions are clearly defined and that the work procedures adopted are able to take effective account of such matters.

2.2 Formality of procedures

2.2.1 It is important to establish responsibility for, and the scope of, the work of all those organizations and individuals involved in preparing and carrying out falsework. These should be clearly defined, both in respect of the structure or structures with which they are concerned, and the duties they should fulfil.

In those instances where, as will often be the case with the smaller schemes, the conception and direction of the falsework is undertaken by an individual, the degree of formalization of procedures may be minimal, although it is necessary to communicate requirements effectively. Where more people are concerned in the

direction and checking of falsework, a formal procedure should be used in order that responsibilities may be properly allocated amongst them and for controlling the communication of requirements and actions.

The key items in both cases are:

- a) responsibility for each of the actions set down in this code should be specifically allocated;
- b) these responsibilities should be clearly defined;
- c) all instructions should be clear and complete.

2.2.2 The main items for which responsibility should be established are:

- a) the design brief (see **2.3** and **6.2**);
- b) the concept of the scheme;
- c) the design, drawing out and specification of the falsework;
- d) the adequacy of the materials used;
- e) the control of erection and dismantling on site, including maintenance;
- f) the checking of design and construction operations;
- g) the issuing of formal permission to load and dismantle the falsework (see **2.8**).

Appropriate procedures can be implemented and the required standards achieved by different management arrangements. These should be established to suit both the nature of the falsework to be carried out and the particular management arrangements of the construction organization(s) concerned. Whatever form of organizational direction and control is set up, it is essential that it has the capability to handle the technical requirements of the falsework adequately. For the smaller job, more than one activity may be undertaken by one individual. In larger jobs, delegation of responsibility for particular tasks will probably take place, but it is important for the avoidance of misunderstandings that those who delegate keep in touch on a day-to-day basis with the activities. Care should be taken that a conflict of responsibilities does not arise.

Of equal importance is the need to ensure that the various responsible individuals do not work in isolation from each other but rather that there is some means adopted to provide effective coordination of all tasks. It is therefore recommended that a falsework coordinator be appointed whose duty it should be to ensure that all the actions required are supervised and performed in accordance with the recommendations of this code (see **2.5.2**).

In many instances, the general details regarding the partitioning of responsibilities amongst individuals or groups of individuals will be governed by the requirements of a contract or contracts agreed between the parties concerned. Indeed, in order to avoid ambiguity as to final responsibilities it is advisable that some form of contract is agreed before work commences.

2.3 Design brief

A brief, summarizing the significant facts, should be prepared (see **6.2.1**) to serve as the starting point for subsequent decisions, design work, calculations and drawings. All concerned should contribute towards the preparation of the brief. An assessment of the brief should also indicate how instructions can most effectively be provided for the direction of the falsework operations.

2.4 Communication of requirements

Falsework designs and schemes should be complete with detailed proposals for the foundations, connections to other works and the formwork, before being offered for use on site. Where the design brief indicates that standard and familiar equipment and materials can be used in accordance with standard details and instructions, it will only be necessary to provide information to those persons on site as to the manner and extent to which the items should be used and maintained to ensure safe practice. These directions should be given in conjunction with an arrangement drawing or sketch. The drawings and any related instructions issued to site for the direction of the work may be supported by, for example, standard details, or guides to the use of proprietary systems of falsework equipment.

The drawings and instructions resulting from the design should generally be adequate to direct the work on site and to enable this to be checked. Particular care should be paid to ensuring that the information supplied is easy to understand, and that it draws attention to the need to resolve any details or unusual situations. The positions of each component and the nature of its cross-connections to other components should be shown. Drawings should be uniquely numbered, clearly identified as to location for use, and cross-referenced to any other data with which they should be used. It is desirable to adopt standard methods of noting essential information on the drawings and to use suitable, easily read scales. To aid the location and identification of particular areas, consideration should be given to applying a system of grid references to the scheme.

Where construction is not straightforward, the falsework drawings are unlikely to set down all the parameters of use. In such cases a method statement or construction plan should be prepared on site and made available to all concerned. Where there are any limitations in sequence or timing, these should be set down explicitly as part of the design for site use.

Instructions should be provided indicating how the supporting foundations should be prepared and emphasizing the need to compare the conditions found on the site with those assumed in the initial design for the purpose of confirming their validity.

2.5 Coordination and supervision

2.5.1 General

Work on site should be the subject of careful direction, supervision and inspection to ensure that the falsework structure is constructed safely in accordance with the agreed design with materials of agreed quality, and that only when all checks have proved satisfactory is the structure first loaded, and then dismantled in accordance with an agreed procedure.

Communication tends to be one of the major problem areas of falsework because of the multiplicity of actions normally required when falsework is being constructed and put into service. Such activities may be widely separated in time and place and it is therefore essential that lines of communication and responsibility are explicit. To facilitate progress, a methodical approach should be adopted and it is recommended that comprehensive job notes are maintained.

2.5.2 Falsework coordinator

2.5.2.1 When a construction organization decides to appoint a falsework coordinator (see **2.2.2**), he should normally be directly responsible to their site manager. It is important that his appointment gives him adequate authority to carry out his tasks. In order to provide adequate authority to stop work if it has not been carried out satisfactorily, it may be appropriate for the falsework coordinator to be made responsible for the provision of formal permission to load, which when signed would thereby certify that all appropriate steps had been taken. The falsework coordinator should not permit erection to continue beyond any critical stage until it is to the standard specified. Once the falsework has been checked and passed, it should not be altered until that loading stage has been completed, and the design allows for it to be dismantled or altered. In demanding circumstances it will be advisable for those checking critical items to sign when the work is to their satisfaction. To ensure the independence of checks, the falsework coordinator should delegate the task to another if he himself has carried out any of the activities requiring checking. His appointment should be made known to all concerned.

2.5.2.2 The principal activities of the falsework coordinator should be to:

- a) coordinate all falsework activities;
- b) ensure that the various responsibilities have been allocated and accepted;
- c) ensure that a design brief has been established with full consultation, is adequate, and is in accord with the actual situation on site;
- d) ensure that a satisfactory falsework design is carried out;
- e) ensure that the design is independently checked for:
 - 1) concept;
 - 2) structural adequacy;
 - 3) compliance with the brief;

- f) where appropriate, ensure that the design is made available to other interested parties, e.g. the structural designer;
- g) register or record the drawings, calculations and other relevant documents relating to the final design;
- h) ensure that those responsible for on-site supervision receive full details of the design, including any limitations associated with it;
- i) ensure that checks are made at appropriate stages covering the more critical factors (see **6.1.3** and **7.4**);
- j) ensure that any proposed changes in materials or construction are checked against the original design and appropriate action taken;
- k) ensure that any agreed changes, or corrections of faults, are correctly carried out on site;
- l) ensure that during use all appropriate maintenance is carried out;
- m) after a final check, issue formal permission to load if this check proves satisfactory;
- n) when it has been confirmed that the permanent structure has attained adequate strength, issue formal permission to dismantle the falsework.

2.6 Checking

At all stages, commencing with the design brief, it is necessary to check that the information being used is correct and that the work carried out is as specified. This is necessary, not only to ensure that a safe and adequate falsework structure is constructed, but also to facilitate rectification should this prove necessary; it is frequently difficult to do this later. Details of checking procedures are given in **6.1.3** and **7.4**.

2.7 Alterations

Changes in the requirements of the design brief should be recorded therein as well as incorporated into the design and drawings (see also **7.4.2**). The effects of any proposed alterations should be checked against the original design and appropriate action taken.

2.8 Loading the falsework

NOTE See also **7.5**.

As a means of exercising a degree of control over the rate of progression once the stage has been reached that the falsework may be loaded, it may be advisable to have a formal procedure for giving permission to load, as indicated in **2.5.2**, perhaps in the form of a “Permit to load”. In simple cases, a single permit, made out as soon as the falsework has been satisfactorily checked, may be appropriate. In complex, or larger cases, permits may be required at different stages, both as regards loading and for different areas. It will normally be desirable to limit the period of validity of the permit, as subsequent modifications may take place. The area over which loading may take place, and to what extent, should also be set down in the permit, e.g. it may be “reinforcement only”.

2.9 Dismantling

When the structure being supported by the falsework has become self-supporting, the latter may be dismantled subject to a previously agreed procedure and/or restrictions imposed by the permanent works (see **7.6**). As at the loading stage, a permit to dismantle or unload the falsework may be appropriate, particularly where this takes place in stages. It may be appropriate to issue it in conjunction with the designer of the permanent structure.

Section 3. Materials and components

3.1 General considerations

3.1.1 Suitability of materials

All materials, when new, should have complied with the requirements of the appropriate British Standard(s).

3.1.2 Identification and properties

Materials and components should be clearly and readily identifiable by shape or size. Where this is not possible they should be marked.

No material should be used unless its properties are known or established, and its application should be within these limits.

3.1.3 Handling of materials and components

Materials and equipment used in falsework will, in most cases, be used many times. In choosing these, account should be taken of the rough conditions under which they will be handled.

Robust material will obviously suffer less damage and mechanical aids that help in this respect should be considered.

3.2 Testing and inspection

3.2.1 Testing

Where doubt exists as to the quality, by composition or condition, of the material or component it may be submitted to a test of the load/deflection type, wherever possible in accordance with an appropriate British Standard specification.

Testing on site is not normally recommended, as even the most simple tests require disciplined test procedures.

If the performance of an item of equipment is not known, or is in doubt and calculations are impracticable, tests should be carried out to determine necessary values. It should be realized that a single test may give misleading results.

3.2.2 Inspection

Materials and components used for falsework should be examined for damage or excessive deterioration before use and if found unsuitable they should be repaired or scrapped. Accepted engineering principles should be applied in determining whether the element requires rejection or remedial work. The integrity of welds should be visually examined, and for a proper examination, paint coatings may have to be removed.

Careful inspection is essential in preventing unfit second-hand material from being used. Welds should be checked and material that is bent, distorted or badly corroded should be scrapped or sent for repair. Items made from steel should be kept in a well-painted condition. Timber should be inspected between uses not only for evidence of physical damage but for signs of attack by decay, rot or insect attack or the development of shakes or splits. Where the surface of the timber is so obscured by dirt, concrete or other coatings as to prevent inspection for defects and deterioration, it should not be used structurally.

Detailed recommendations for the reuse of used materials are given in 3.3 to 3.9.

3.3 Steelwork (other than scaffold tube)

NOTE Specific recommendations for tubular steel scaffolding and manufactured components are given in 3.8 and 3.9 respectively.

3.3.1 Quality of steel

Except in cases where particular properties are desirable, weldable structural steel of a higher grade than grade S 275JR (grade Fe 430B) of BS EN 10025 should not be specified. If the material properties are not known, steel should be assumed to be mild steel grade S 235 JR (grade Fe 360B) of BS EN 10025 for design purposes (but see 3.3.6 for welding). For design purposes, old steel of grade 43A may be assumed to be equivalent to grade S275 of BS EN 10025 if it was manufactured in accordance with the 1986 or 1990 editions of BS 4360. Old steel of grade 43A manufactured to previous editions of BS 4360 should be assumed to have a strength midway between grades S235 and S275.

3.3.2 Identification of steel

It is of the utmost importance that the correct quality, size and mass of section should be used. Each element should be clearly marked to assist erection and inspection. The permanent marks, formed when a section is rolled, may not give any indication of quality, mass or true size. Attention is drawn to the differences between rolled steel joists (RSJ) and universal beam (UB) sections, the latter often having thinner webs and dimensions that are nominal only and vary with the particular mass per unit length.

Where steelwork other than mild steel is used for particular properties, it should be so marked as to be readily distinguishable and any connections should be designed to obviate substitution errors.

3.3.3 Permissible stresses

The permissible stresses should be based on the allowable stresses given in BS 449-2:1969 according to the steel being used, as follows.

- a) The BS 449 allowable stresses for grade 43 should be used for grade S275 steel to BS EN 10025 and for old grade 43 steel to BS 4360:1990 or 1986.
- b) For old grade 43 steel to editions of BS 4360 prior to 1986 the BS 449 allowable stresses for grade 43 steel should be divided by 1.1.
- c) For grade S235 steel to BS EN 10025 and for unidentified mild steel, the BS 449 values for grade 43 steel should be divided by 1.2. See Annex A, Table A.2.

3.3.4 Section properties

Where the cross-sectional area of a steel section has been reduced, the actual dimensions should be measured and section properties calculated on the basis of the least cross-sectional area. If such measurements are not possible owing to heavy corrosion or any other reason, load testing should be carried out.

3.3.5 Fatigue

There is normally no need to consider fatigue when designing falsework.

3.3.6 Welding and rectification of steelwork

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 BS 5135. The quality of steel being repaired should first be identified.

Bent sections should be carefully straightened and the work should be carried out preferably by means of straightening rolls, hydraulic press or other controlled method.

Where, for any member to be used as a strut, the lack of straightness is clearly visible to the eye, or exceeds the appropriate tolerances recommended in 7.3.2, the member should be straightened or discarded.

3.4 Timber

3.4.1 Timber quality

3.4.1.1 General

Timber for falsework should be stress graded in accordance with BS 4978 or other appropriate standards of other countries. A full range of stresses for both softwood and hardwood is given in BS 5268-2. That standard also gives a simplified approach to stress grading by using nine rationalized strength classes, enabling a variety of species to be used efficiently. Data on strength classes SC3 to SC5 are given in Table 1.

Details of equivalent timber grades satisfying these various strength classes are given in Table 2 and Table 3. Alternatively, timber may be graded directly to a particular strength class.

3.4.1.2 Minimum quality

It is recommended that strength class SC3 timber should be the minimum quality adopted for general use although any timber may be used provided proper account is taken of the appropriate stresses.

A species/grade combination for a higher strength class may safely be used where a lower strength class is specified. The highest grade is M75. Others in descending order, are: SS; M50; GS. MSS and MGS are equivalent to SS and GS respectively. For grading to NLGA rules, the strongest is Selected (Sel) followed by No. 1, No. 2 and No. 3 or a sequence of "Const", "Std", "Util" and "Stud".

Table 1 — Basic stresses and moduli of elasticity for the wet condition

Strength class	Bending stress parallel to grain N/mm ²	Tensile stress parallel to grain N/mm ²	Compressive stress perpendicular to grain N/mm ²	Shear stress parallel to grain N/mm ²	Modulus of elasticity	
					Mean N/mm ²	Minimum N/mm ²
SC3	4.24	2.56	1.32	0.60	7 000	4 600
SC4	6.00	3.60	1.44	0.64	7 900	5 300
SC5	8.00	4.80	1.68	0.90	8 600	5 700

NOTE 1 This table is based on BS 5268-2:1991. The values take into account the modification factor for the wet condition in that code.

NOTE 2 Timber in the wet condition has a moisture content greater than 18 %.

Table 2 — Equivalent strength classes for softwoods graded in accordance with BS 4978

Standard name	Strength class		
	SC3	SC4	SC5
<i>Imported</i>			
Douglas fir-larch (Canada)	GS	SS	—
Douglas fir-larch (USA)	GS	SS	—
Hem-fir (Canada)	GS, M50	SS	M75
Hem-fir (USA)	GS	SS	—
Parana pine	GS	SS	—
Pitch pine (Caribbean)	GS	—	SS
Redwood	GS, M50	SS	M75
Sitka spruce (Canada)	SS	—	—
Southern pine (USA)	GS	SS	—
Spruce-pine-fir (Canada)	SS, M50	SS, M75	—
Western whitewoods (USA)	SS	—	—
Whitewood	GS, M50	SS	M75
<i>British grown</i>			
Corsican pine	M50	SS	M75
Douglas fir	SS, M50	—	M75
European spruce	M75	—	—
Larch	GS	SS	—
Scots pine	GS, M50	SS	M75
Sitka spruce	M75	—	—

NOTE Machine grades MGS and MSS may be substituted for the GS (general structural) and SS (special structural) grades respectively.

Table 3 — Equivalent strength classes for North American softwoods graded in accordance with NLGA and NGRDL joist and plank grades^a

Standard name and origin	Strength class		
	SC3	SC4	SC5
Douglas fir-larch (Canada)	No. 1, No. 2	Sel	—
Douglas fir-larch (USA)	No. 1, No. 2	Sel	—
Hem-fir (Canada) ^a	No. 1, No. 2	Sel	—
Hem-fir (USA)	No. 1, No. 2	Sel	—
Sitka spruce (Canada) ^a	Sel	—	—
Southern pine (USA)	No. 1, No. 2, No 3	—	Sel
Spruce-pine-fir (Canada) ^a	No. 1, No. 2	Sel	—
Western whitewoods (USA) ^a	Sel	—	—
NOTE The classifications in this table apply only to timber of a size not less than 38 mm × 114 mm.			
^a NLGA [National grading rules for dimension lumber (Canada)]. NGRDL [National grading rules for softwood dimension lumber (USA)].			

3.4.1.3 Hardwood and softwood

Many hardwoods are denser and stronger than softwoods but the strength classification system applies equally to both. For load-bearing wedges and packings, the higher strengths available only from the denser hardwoods will be desirable. Most straight-grained hardwoods whose density exceeds approximately 650 kg/m³ will be suitable for such wedges. The following list details some commonly available, hardwood species suitable for use as load-bearing wedges and packing:

Standard name	Botanical species
ash	<i>Fraxinus excelsior</i>
beech	<i>Fagus sylvatica</i>
greenheart	<i>Ocotea rodiaei</i>
jarrah	<i>Eucalyptus marginata</i>
karri	<i>Eucalyptus diversicolor</i>
keruing	<i>Dipterocarpus spp</i>
oak	<i>Quercus spp</i>

3.4.1.4 Stress graded timber

Timber that has been accepted as stress graded carries appropriate marking, comprising a stamp on at least one face, edge or end to indicate the grade. In the case of timber machine stress graded in accordance with BS 4978, the BSI Kitemark usually appears. Sometimes, as a result of the process of machine stress grading, the timber has coloured marks at intermediate points indicating the grade near each point. The lowest strength found at any of these intermediate points dictates the overall classification of the piece.

Machine stress graded timber is assessed about its lesser dimension, so if used on edge, a check should be made to see that there are no splits or knot combinations that would result in down grading.

3.4.2 Modification factors

3.4.2.1 General

The basic stresses given in Table 1 should be multiplied by the appropriate modification factors in 3.4.2.2 to 3.4.2.10.

3.4.2.2 Moisture content

The data given in Table 1 relates to timber with a moisture content greater than 18 %. If, in the exceptional case, the timber has a lower moisture content, higher stresses may be used in accordance with BS 5268-2:1991. However, these are seldom appropriate for falsework.

3.4.2.3 Size

Timber swells across the grain as it gets wetter. Because timber is sold as the “dry size”, under site conditions it will normally be larger. Table 4 gives appropriate values for modification factor K_1 . In all calculations, actual and not nominal sizes of timber should be used.

Table 4 — Modification factor, K_1 , by which the geometrical properties of timber for the dry exposure condition should be multiplied to obtain values for the wet exposure condition

Property	K_1
Thickness, width and radius of gyration	1.02
Cross-sectional area	1.04
First moment of area, section modulus	1.06
Second moment of area	1.08

3.4.2.4 Time

The basic stresses given in Table 1 are for timber under load for 50 years but timber will safely sustain higher stresses for shorter periods. Table 5 gives appropriate values for modification factor K_3 . The effect is cumulative over the life of the timber, unless the time lapse between loadings is at least equal to the time during which loads have been imposed.

Table 5 — Modification factor, K_3 , for duration of load on falsework

Duration of loading	K_3
1 year	1.2
1 month	1.3
1 week	1.4

3.4.2.5 Compression perpendicular to the grain

There should be no wane at bearing positions. The stresses given in Table 1 to Table 9 assume that there will be no wane or other loss of section at these points; if there is, the stresses should be halved. In no case should wane exceed that permitted in BS 4978.

Stresses for compression in Table 1 may be increased by a factor of 1.2 to give values appropriate to falsework.

Where the bearing area is short along the grain, a higher stress may be taken, provided that there is at least 75 mm of timber each side of the bearing. Appropriate values for modification factor K_4 are given in Table 6.

3.4.2.6 Compression parallel to the grain

If it is intended to use timber as struts, reference should be made to BS 5268-2:1991 for appropriate stresses.

Table 6 — Modification factor, K_4 , for bearing stresses

Max. length of bearing mm	K_4
10	1.74
15	1.67
25	1.53
40	1.33
50	1.20
75	1.14
100	1.10
150 or greater	1.00

3.4.2.7 Depth-to-breadth ratios

There is a risk of tall timbers turning sideways. Table 7 gives the ratios that should not be exceeded.

Table 7 — Maximum depth-to-breadth ratios

Degree of lateral support	Maximum depth-to-breadth ratio
No lateral support	2:1
Ends held in position	3:1
Ends held in position and member held in line, e.g. by purlins or tie-rods	4:1
Ends held in position and compression edge held in line, e.g. by direct connection of soffit formwork	5:1
Ends held in position and compression edge held in line, e.g. by direct connection of soffit formwork together with adequate bridging or blocking spaced at intervals not exceeding six times the depth	6:1
Ends held in position and both edges held firmly in line	7:1

3.4.2.8 Shear

The values for stress parallel to the grain given in Table 1 may be increased by a factor of 1.5 to give the permissible stress across the grain.

The maximum stress should be calculated initially by dividing the shear force by the cross-sectional area. This value should then be multiplied by 1.5 (the distribution is parabolic). Care should be taken to see that splits are not positioned where a high shear is expected (see 3.4.4).

3.4.2.9 Modulus of elasticity

The modulus of elasticity varies with moisture content, but not with time and thus the modification factor K_1 is applicable, but not K_3 . (See also 3.4.2.10.)

3.4.2.10 Load sharing

Where a single member may carry its full share of the load unaided by its neighbours, the appropriate working stresses and the minimum value of modulus of elasticity should be used, but if members are spaced not more than 610 mm apart, and there is adequate provision for lateral distribution of loads by means of decking or joists spanning at least four supports, stresses may be increased by a factor of 1.1.

For the calculation of deflection of load-sharing systems, the mean value for the modulus of elasticity should be used.

3.4.2.11 Depth

The data for bending stress parallel to the grain given in Table 1 and Table 9 are applicable to timber which is 300 mm deep. For beams between 72 mm and 300 mm in depth, slightly higher figures are appropriate. These permissible stresses are given in Table 8. For timbers more than 300 mm deep, see 14.6 of BS 5268-2:1991, which makes adjustments using factor K_7 .

This approach may also be used for timbers with a depth less than 300 mm as an alternative to Table 8.

Table 8 — Permissible bending stress parallel to the grain for beams of different depths for general falsework applications

Nominal depth range (mm)	up to 72	73 to 100	101 to 125	126 to 150	151 to 200	201 to 225	226 to 300
Timber class (N/mm ²)							
SC 3	7.36	7.10	6.93	6.79	6.58	6.49	6.29
SC 4	10.42	10.05	9.80	9.61	9.31	9.19	8.90
SC 5	13.89	13.40	13.07	12.81	12.41	12.25	11.87

3.4.2.12 Permissible stresses

The stresses given in Table 9 may be used for calculations if the following conditions apply (the modification factors described in 3.4.2 have already been applied):

- the timber has been accepted as appropriate to the class concerned;
- sizes for dry timber are used;
- the duration of the load does not exceed one week;
- there is no wane;
- the bearing length does not exceed 75 mm, there is at least 75 mm of timber each side of the bearing, and take-up is not critical;
- the depth-to-breadth ratios of Table 7 are not exceeded.

Table 9 — Permissible stresses and moduli of elasticity for general falsework applications

Strength class	Bending stress parallel to grain N/mm ²	Tensile stress parallel to grain N/mm ²	Compressive stress perpendicular to grain N/mm ²	Shear stress perpendicular to grain N/mm ²	Modulus of elasticity <i>E</i>	
					Mean N/mm ²	Minimum N/mm ²
SC 3	6.29	3.73	2.63	1.32	7600	5000
SC 4	8.90	5.24	2.87	1.40	8600	5700
SC 5	11.87	6.99	3.35	1.97	9200	6100

3.4.3 Timber that is not stress graded

Where it is not possible to obtain appropriate stress graded timber, commercially graded timber may be used instead provided unsuitable material is removed from the batch; this should be carried out in accordance with the visual stress grading rules of BS 4978.

Care should be taken that what is being supplied is not the reject fraction from stress grading. Commercial grade timber that may prove suitable is listed in Table 10.

Table 10 — Commercial grade timber suitable to produce mainly class SC3 timber

Standard name	Commercial description
Czech whitewood (Ligna)	Unsorted
Finnish, Swedish and Polish redwood and whitewood	Fifths "V"
Pacific coast Douglas fir, hemlock, western whitewoods and spruce	1 and 2 merchantable
Russian redwood and whitewood	Fourths "IV"

3.4.4 Grading reused timber

Where the origin and grading of the material is no longer known, it can be regraded, when the species is known, although this should be done by a person capable of such work.

Cross cutting will not reduce the grading, but when timber is rip-sawn after stress grading, the original grading will no longer be valid.

Timber should be discarded if any of the following are present:

- it has been painted such that it prevents assessment;
- there is any sign of rot, fungal or chemical;
- there are cuts in the edge greater than one-twentieth of the thickness of the section;
- there are holes in the two outer thirds;
- there is other mechanical damage;
- there is any undue distortion of shape;
- in the case of timber to be used for beams or columns, there is a piece containing any fissures at slopes greater than 1:6 for class SC3 or 1:10 for class SC4.

In cases c) and d), the design may be based on the remaining good section.

Timber should never be reused without a careful inspection.

3.5 Concrete and concrete components

3.5.1 Mix design

The concrete should, in general, comply with the permanent works specification appropriate to its intended location, e.g.:

- a) blinding;
- b) spread footings;
- c) piles;
- d) pile caps;
- e) structural members.

Relaxation of the specification, however, may be permitted to allow for its temporary function. The following are unlikely to be of significance over a short period:

- 1) conversion of high alumina cement;
- 2) attack of Portland cement concrete in sulfate-bearing ground;
- 3) attack of reinforcement due to calcium chloride.

3.5.2 Blinding concrete

Blinding concrete is intended only to prevent local degradation of the soil and to provide an even surface. Its thickness should be not less than 50 mm. The allowable bearing pressure should be the same as that of the underlying soil or weak rock, up to a maximum of 2 000 kN/m².

3.5.3 Spread footings

Mass concrete intended to transfer load direct to the ground and more than 100 mm thick should be regarded as a spread footing. Spreading from the perimeter of load at an angle of 45° to the axis of the load may be assumed in calculating the bearing pressure on the ground.

3.5.4 New structural members

New structural members should be designed and constructed in accordance with the specifications for the permanent works except in so far as their temporary function permits relaxation of serviceability requirements. For example, it may be possible to:

- a) reduce cover to the reinforcement;
- b) neglect long-term creep deflections;
- c) accept greater crack widths;
- d) accept higher deflections.

Care should be taken to ensure that the concrete is of adequate strength before any load is applied to it. Guidance on the age at which load may be applied to structural members is given in CIRIA Report No. 136 [6]

3.5.5 Second-hand structural members

Any concrete member not specifically designed for a particular project should not be used unless all the following are satisfied:

- a) the position and sizes of the reinforcement and the strength of the concrete are known or can be ascertained;
- b) the member is free from excessive cracking, spalling, or visible or known defect;
- c) the member has been subjected to a design check and found adequate for its proposed use.

3.5.6 Precast concrete

Precast concrete members forming part of a falsework system should be manufactured in accordance with the recommendations of BS 8110-1, -2 and -3. In the case of symmetrical sections having the principal reinforcement on only one face, the members should be clearly marked to indicate the way they should be used or, alternatively, the reinforcement should be designed to enable the member to serve its design performance whichever way up it is erected.

Special attention should be paid to concrete used as permanent formwork and subsequently used in composite construction. In some instances temporary supporting falsework may be required during the placing of in situ concrete on top. Consideration should be given to stresses and deflections that may be locked into the precast concrete members before composite action is assured.

3.6 Brickwork and blockwork

3.6.1 Characteristic strength

Characteristic strengths for brickwork and blockwork should not exceed those recommended in BS 5628-1.

3.6.2 Rate of building

Where brickwork is to be load bearing, the rate of building should be restricted to a maximum height of 1.5 m per day for normal construction in bricks with a compressive strength of up to 35 N/mm². No one portion should rise more than 1 m above the level of adjacent brickwork. Bricks of higher compressive strength usually have a higher density and lower absorption and because of this it may be necessary to limit the height of the building per day still further.

3.6.3 Age of loading

If the loading is to be applied less than 28 days after completion of the brickwork or blockwork, characteristic strengths in compression should be calculated in accordance with Table 2 of BS 5628-1:1978. Brickwork or blockwork should not be loaded at less than 7 days and preferably not less than 14 days after completion of the work.

3.6.4 Reinforced brickwork and blockwork

Only new materials should be used for reinforced brickwork and blockwork, which should satisfy the recommendations of BS 5628-1.

3.6.5 Salvaged bricks and blocks

Salvaged bricks and blocks may be used for falsework other than in situations given in 3.6.4 provided that they are sound and free from contamination (e.g. gypsum plaster) that might adversely affect the mortar or its bond with the bricks or blocks, or have any other adverse effect on the structure.

The permissible characteristic strength in compression should be calculated as recommended in BS 5628-1, using a unit crushing strength of the bricks of 3 N/mm² for stock bricks and 5 N/mm² for other types.

Where salvaged bricks are used, it should be assumed that unreinforced brickwork possesses no tensile strength.

3.7 Other materials

3.7.1 General

Where the material chosen for falsework is not among those described in 3.3, 3.4, 3.5 and 3.6, the approach described in this clause should lead to the use of satisfactory working stresses. In all cases where British Standard codes of practice exist, the design and usage of these materials should conform to the recommendation of the appropriate clauses of those codes (e.g. for aluminium use BS 8118).

3.7.2 Permissible stresses

The supplier of the material should be called upon to provide sufficient information and test data to enable suitable permissible stresses to be established. Two of the variables requiring consideration are creep and the duration of loading.

3.7.3 Deterioration

Unfamiliar materials may deteriorate in unexpected ways but at least the following should be considered:

- a) fatigue;
- b) heat;
- c) chemical deterioration;
- d) organic or ultraviolet deterioration;
- e) animal or bacteriological action;
- f) deformation or lack of straightness;
- g) local adaptations that have caused loss of cross-sectional area.

Such deterioration should be identified by examination of materials when their use is proposed and allowance made, if necessary after testing.

3.8 Steel scaffold tubes, couplers and other fittings

3.8.1 Equipment in general use

Most equipment in use in the UK comprises 4.0 mm thick (8 SWG) steel tube of 48.3 mm outside diameter complying with the requirements of BS 1139. New steel tube should comply with BS 1139-1.1:1990. A large quantity of steel tube made in accordance with BS 1139-1:1982 is still in use. Properties in accordance with these two standards are given in Annex B. Test loads are also given in BS 1139 for various couplers and fittings.

Steel and aluminium alloy tubes should not normally be used in the same structure, but if it is necessary to do so the difference in their properties should be allowed for in the design. Their properties should be obtained from the appropriate British Standards.

3.8.2 Non-standard scaffold tubes

Attention is drawn to the existence of steel scaffold tubes having a wall thickness less than 4 mm and that do not comply with the requirements of BS 1139, but that do have the same 48.3 mm outside diameter. Such tubes are in general use in some countries abroad, but are not recommended for use in the UK owing to the risk of inadvertent substitution.

Tubes of a higher grade, greater thickness and diameter are available as well as open-jointed tube. Data for tubes other than those complying with the requirements of BS 1139 are not given in this code.

3.8.3 Loads on struts

Safe working loads on mild steel scaffold tube struts are given in Annex B. The allowable stresses adopted are in accordance with BS 1139. An overall K_2 factor of 2.00 is used; this will allow for some corrosion and will be appropriate for the eccentricity of load application and transmission through couplers. If other tubular members are used, the material is likely to comply with the requirements of BS EN 10210-1 in conjunction with BS 4848-2 and for suitable permissible loads the appropriate data from these British Standards should be used in the formula indicated in Annex B.

The tolerances specified for erection should be in accordance with 7.3.2.3. Where it is expected that loads will not be applied within these tolerances, the safe working load may be considerably lower and should be specifically calculated.

To determine a safe working load for the strut of length L between the centre-to-centre of intersections with supporting members, its effective length l should be calculated as described in 6.7.2.

3.8.4 Straightening of scaffold tubes

Bent steel tube may be straightened by using a crow or a reeling machine. This operation should be carried out under competent supervision. Reeling should not be used to straighten bent aluminium scaffold tube. A bent scaffold tube should not be used until straightened by an approved method and returned to within permissible tolerances (see Annex B).

3.8.5 Corrosion and deterioration of steel scaffold tube and fittings

Steel scaffold tubing that is corroded to the extent of rust flaking or severe pitting of the surface should be cleaned of all loose material. It should then be measured for external diameter and checked against the minimum requirements of BS 1139 as given in the summary of properties and tolerances in Annex B. Particular attention should be paid to the 75 mm length at the end of the tube, as this tends to corrode more than the rest of the tube.

Scaffold tube should be free from cracks and should have the ends cut square, smooth and free from burrs. Sections of tube that have been seriously deformed or creased by abuse should be cut out and discarded. Where tubes have become thin or split at the ends, these should be cut off, all such cuts being at right angles to the axis of the tube.

3.8.6 Scaffold fittings

Annex B gives safe working loads for couplers and some other fittings complying with the requirements of both the 1982 and 1991 editions of BS 1139. In many cases, scaffold fittings have strengths greater than the minima required by BS 1139. Should the fittings be tested in accordance with the methods specified in BS 1139 and the failure loads are higher than the minimum required, the working loads may be based on the failure loads actually obtained by applying a factor of safety against slipping of 2.0 where this loading is required.

Where working loads higher than 6.3 kN arrived at by this means are used in design, particular care should be taken to ensure that only fittings of the type tested are used.

Care should be taken not to substitute right angle or swivel couplers with others, such as putlog couplers, having a lower load carrying capacity than 6.3 kN or 5.3 kN respectively.

NOTE For loads on supplementary couplers see 6.7.1.

3.8.7 Deterioration of scaffold couplers and fittings

Fittings should be inspected before use and should not be used if they are damaged in any way that would reduce their efficiency. It is necessary to ensure that the threads are not damaged so that there can be no confusion over whether the fitting has been tightened to the tube or to the damaged thread. Damaged fittings should be removed from the site for remedial treatment before use.

Baseplates should be checked to ensure the integrity of the welds, the squareness of the base to the stem and the planeness of the base.

3.9 Manufactured components for falsework

3.9.1 Types of manufactured components

The following are examples of manufactured components:

- a) framed tower components for vertical load bearing;
- b) adjustable steel props;
- c) adjustable steel centres for bridging between beams;
- d) bridging girders;
- e) soldiers.

3.9.2 Design and testing of manufactured components

When structural analysis of a component or system is not practical, tests will be necessary to establish the performance. Annex C gives recommendations for testing falsework equipment.

3.9.3 Information from the supplier

Information necessary for the design, erection, use, dismantling and maintenance of the components offered as falsework should be available from the supplier.

This information should relate to the properties of the individual components, their use in expected assemblies, and any specific requirements for inspection and maintenance, and should include the following:

- a) the intended uses for the components, how they can be identified, and the appropriate dimensions and masses;
- b) whether the components comply with the requirements of an appropriate British Standard or standard;
- c) details of connections where loads are received into one or more components, transferred from one to the other, and transmitted to other supports such as foundations;
- d) recommended maximum working loads for various conditions of use, such as different extensions and eccentricities, together with details of any necessary bracing or lacing;
- e) any limiting deflection conditions.

Continuing quality control of manufacture should be ensured.

3.9.4 Factors of safety

Where the strength of a manufactured component cannot be ascertained by applying the design criteria recommended in this code, it should be determined by applying a minimum factor of safety against collapse of 2.0 when tested in a condition equivalent to the worst acceptable condition described in this code (see Section 7) or actual site condition likely to apply. An appreciably larger factor of safety will be appropriate for materials that have a wide scatter of strengths.

3.9.5 Framed tower components for vertical load bearing

Prefabricated components usually assemble into rectangular towers, of which the perpendicular load-bearing members are frequently in pairs, but towers may also be square or triangular, or have many legs. There may be separate bracing members, but in most cases assembly is simple. The adjustment needed to make the tower vertical will be very small if the base is level.

Because a number of assumptions have to be made to enable BS 449-2 to be used for calculations, testing may need to be carried out. A height of at least 5 m should be adopted, and appropriate horizontal loading included in the test. Where some lateral restraint is needed, this should be clearly stated in the instructions for use.

The components should be made within the tolerances assumed in the design. Because there are many joints, the total tolerance may be significant. There will be some take up at the joints as the load is applied, and the anticipated distribution of load in the legs may become modified. Allowance should be made so that the final level at the top is that required.

Where testing of prefabricated towers is required, the procedures described in DD 89 should be followed.

NOTE DD 89 (now withdrawn) covered the testing of prefabricated towers. The procedures are currently being updated and will be issued as a CEN standard.

3.9.6 Adjustable steel props

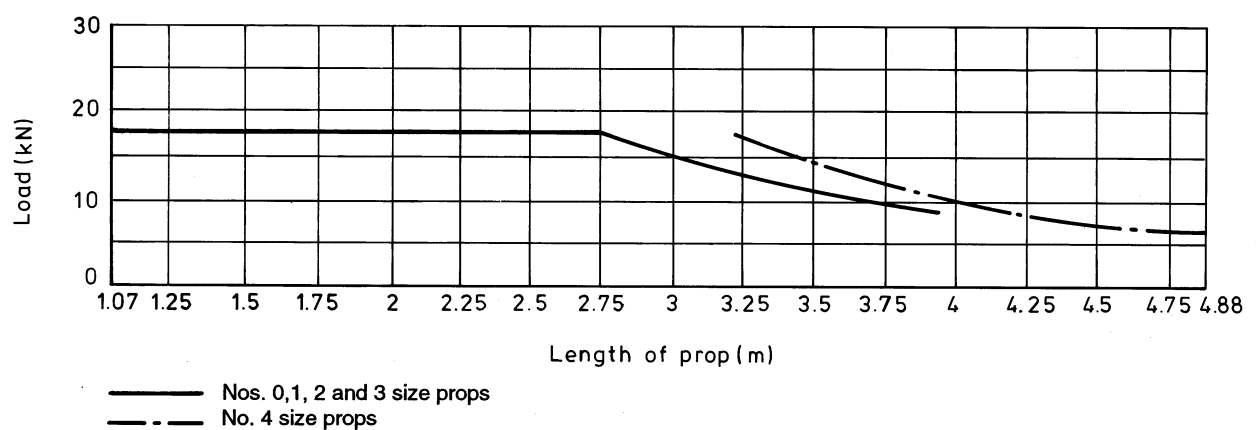
Steel props should comply with the requirements of BS 4074, in which the construction and sizes of adjustable steel props are specified. A prop comprises telescopic tubular sections with top and bottom plates approximately 150 mm square. The transfer of load between the two parts is by an adjustable collar and a pin. The pin is of high tensile steel, and should only be replaced with one of the appropriate type. Table 11, based on BS 4074, gives the height ranges of props according to their size number.

Figure 1a) gives the safe working loads for props erected to the maximum erection tolerances permitted under the recommendations of 7.3.2.2. A prop will carry its maximum safe working load when it is plumb and loaded concentrically. Where concentric loading can be guaranteed, e.g. by placing the loading member in a forkhead and twisting it to ensure the member is central, the higher loadings indicated in Figure 1b) may be used.

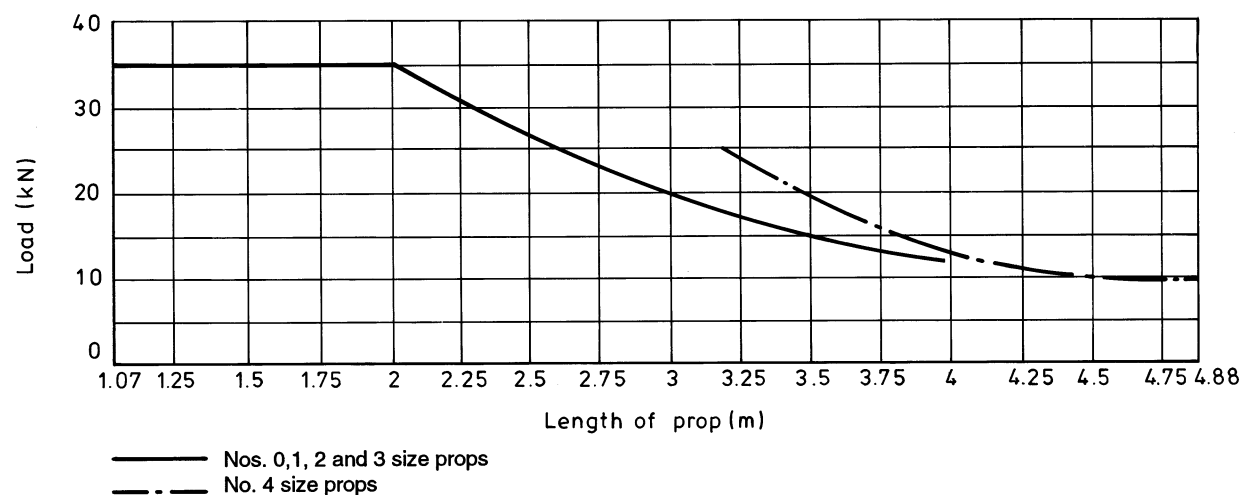
Where testing of props is required, such testing should be carried out in accordance with BS 5507-3.

Table 11 — Adjustable steel prop heights

Prop size no.	Range of prop height mm	
	min.	max.
0	1 070	1 820
1	1 750	3 120
2	1 980	3 350
3	2 590	3 960
4	3 200	4 870



a) Safe working loads for props erected 1.5° maximum out-of-plumb and with up to 25 mm maximum eccentricity of loading (i.e. concentric loading cannot be ensured)



b) Safe working loads for props erected 1.5° maximum out-of-plumb and with concentric loading ensured

Figure 1 — Safe working loads for props

3.9.7 Floor centres

Floor centres normally comprise two (or more) fabricated steel beams, usually of lattice or box construction, that can slide within each other to give the desired length. An overlap at the middle provides strength and continuity between the two sections. The ends are flat plates level with the top surface, which transfer the shear forces to the supports.

Floor centres are usually made with a built-in camber because they deflect significantly under load. However, it is difficult to achieve a precise result, and where accuracy is important, or where the loading is too great for the span, an intermediate prop may be considered. However, as some floor centres cannot accept a prop, and the correct location is very important, it is imperative to follow the instructions supplied with the equipment.

Where the capacity is to be established by test, floor centres should be tested in accordance with BS 5507-1. The safe working load of these floor centres should be used with a factor of safety of 2.0 related to the onset of yield. The design of the floor centres should be such that visible deformation will take place before final collapse occurs.

3.9.8 Bridging girders

Many types of proprietary systems are in use, e.g. the Bailey Bridge, and most are created by the assembly of panels or other structural components. It is important to refer to the information provided with the equipment concerning the correct method of assembly and lifting. Where torque spanners are required in erection it is essential to see that they are correctly set. Where lateral bracing is specified between girders this should always be fixed before any other loads are applied to the girders. The recommendations in the information supplied with the equipment and the relevant assembly instructions should be used both in design and erection, to check the assembly stability and support arrangements.

Because of the long life of these panels, together with the nature of the loading to which they may have previously been subjected when used in bridges, it is important to inspect the panels for signs of fatigue in addition to signs of damage or corrosive deterioration (see Annex D). Where systems are pinned rather than bolted together, particular care should be taken in assessing deflections and any initial movement of connections. In critical cases, preloading should be considered.

3.9.9 Military trestling systems

Various types of military trestling are still in use but it is recommended that work utilizing this equipment is only designed or executed by persons having specialized knowledge of the equipment. Attention is drawn to the reduced capacity of some of the more recently manufactured components.

The members should be carefully examined for signs of corrosion or damage, particularly at the column channel section between batten plates.

No holes should be drilled in the trestling members, nor additions made, without the approval of a structural designer familiar with this type of equipment.

Section 4. Loads applied to falsework

4.1 General

Falsework should be designed to cater for:

- a) self-weights;
- b) imposed loads;
- c) environmental loads.

Wherever possible, the precise loading conditions and the exact weights of materials should be ascertained. If estimated allowances are used for design purposes, a check should be carried out when details of the falsework and loading conditions are known and the design confirmed or amended as necessary.

4.2 Weights of materials

Where not given in this code, self-weights of materials should be taken from BS 648 and imposed loads taken from BS 6399-1. Recommended figures for the masses and densities of some commonly used materials are given in Annex E. For the purposes of this code, a standard density value for reinforced concrete of $2\,500\text{ kg/m}^3$ is recommended, with aggregates of normal density and up to 2 % reinforcement (for guidance on variations to this figure see Annex E).

4.3 Self-weights

The total self-weight should include the self-weight of:

- a) the falsework structure;
- b) any ancillary temporary works connected to the falsework, e.g.:
 - 1) access ramps;
 - 2) hoist and other tower structures;
 - 3) loading storage platforms;
 - 4) raking and flying shores;
- c) the formwork;
- d) any permanent works elements forming an integral part of the formwork and falsework.

4.4 Imposed loads

4.4.1 General

Imposed loads should include the loading from:

- a) permanent works, e.g. reinforcement and concrete;
- b) construction operations, including:
 - 1) working areas;
 - 2) storage areas;
 - 3) pedestrian traffic;
 - 4) vehicular traffic;
 - 5) static plant;
 - 6) mobile plant.

4.4.2 Permanent works loading

The permanent works loading should be assessed from the self-weight of the permanent structure supported by the falsework.

Where impact may occur in the placing of permanent works elements, an extra vertical load should be assumed, which will require assessment in each case. For example, for a unit weighing 5 t (tonnes), with normal crane operation, an additional 50 % of the unit's mass should be allowed. For a piece of steelwork weighing 100 t, crane control would normally be more careful and an allowance of an extra 10 % may then be appropriate.

The local effect of impact and heaping during concreting operations is catered for in the loading given for working areas (see 4.4.3.1).

The loading effects of movements due to shrinkage, creep, thermal changes and post tensioning are considered in Section 6.

When concrete is placed against or upon formwork surfaces, they will be subjected to forces that may have vertical and horizontal components. In some cases, e.g. where void formers or top formwork are used, uplift forces may be created.

The forces exerted by concrete should be calculated using either the method set out in CIRIA Report No. 108 [4] or an estimate of the concrete pressure (expressed in kN/m^2) may be based conservatively on 25 times the depth of pour (in m). The latter method should be used where the concrete will apply a full hydrostatic head to the formwork as would be the case when using certain admixtures.

4.4.3 Construction operations

4.4.3.1 Working areas

Allowance should be made for access and working area loading on the falsework.

A loading of 1.5 kN/m^2 is recommended to allow for the following situations:

- a) construction operatives;
- b) hand tools and small equipment commonly used in reinforced concrete construction;
- c) materials required for immediate use;
- d) the common situations of impact and heaping of concrete occurring during placing operations.

For this loading allowance to be valid, the concrete should not be dropped into the reception arrangements or on to horizontal surfaces from a free height greater than 1 m, nor should the concrete be allowed to heap and accumulate on the formwork to a height more than three times the depth of the slab, with a limit in area for any such accumulation to this height of 1 m^2 (see Figure 2). Should it be necessary to exceed these limitations, allowance for the additional loading should be made in the design.

Where allowance has only to be made for access and inspection purposes, a loading of 0.75 kN/m^2 should be adequate.

These loadings are for access and working conditions. They are not intended to allow for the stacking of materials or for the loads of other equipment and plant for which specific provisions should be made as described in 4.4.3.2 and 4.4.3.4.

4.4.3.2 Storage areas

Where materials to be stored on the working area produce concentrated or distributed pressures greater than 1.5 kN/m^2 , provision should be made in the design for the additional loading. This provision should either extend over the whole of the working area or the storage areas should be specifically designated and clearly marked on the drawings and on the site. The limits of the area, the nature of the materials to be stored and the height to which the materials may be stacked, hence the intensity of loading, should be clearly defined and communicated in a form suitable for use and understanding on site. Similar precautions will be necessary to guard against excessive storage of materials on a recently formed deck before this is self-supporting.

4.4.3.3 Traffic

Where passage is required through or adjacent to areas on which falsework operations are taking place, appropriate arrangements should be made for the protection of vehicles and people using these access ways.

Where vehicles or people are required to be able to enter falsework working areas, provision should be made for the resulting loadings. Where no entry or passage of vehicles or people is allowed for in the falsework design, adequate arrangements with barriers and notices should be provided to prevent such passage. Protective arrangements to minimize the consequences of impacts should include means to give early warning to drivers by the use of notices, load gauges, light-weight screens, etc.

The following loading allowances are recommended:

- a) pedestrians (members of the public): 4.0 kN/m²;
- b) pedestrian access barriers: 0.75 kN/m applied in any direction;
- c) vehicles on falsework: use appropriate axle or wheel loads with allowance for impact of 11.25 t maximum;
- d) vehicle crash barriers: 7.5 kN/m applied in any direction.

NOTE Reference should be made to BS 6180 for special barriers.

4.4.3.4 Plant (including construction vehicles)

Imposed loads from items of plant should include the self-weight of the plant plus any load it will carry.

a) *Vibration*. In general, plant vibration is unlikely to cause any significant increase in loading. However, the loosening effects on bolts, wedges and other friction connections should be considered, particularly when external vibrators are used.

b) *Dynamic loading from loads moving vertically*. The static loading of the moving item should be increased by 25 % when using mechanically operated lifting gear, and by 10 % when using manually operated lifting gear.

c) *Dynamic loading from loads moving horizontally*. This loading results from moving plant, or from loads being deposited by lifting equipment positioned on or off the falsework or being carried across the falsework by plant or on moving equipment. The design should allow for a horizontal force in any of the possible directions of movement equivalent to 10 % of the static load of the moving items where the rate of travel cannot exceed 2 m/s. Without this speed limitation the horizontal force should equate to 33⅓ % of the moving load.

d) *Impact*. The consequences of suspended loads impacting on falsework should be considered in the light of the damage that would result.

e) *Concrete pumping*. Where concrete is being placed by pump or pneumatic placer through a pipeline carried on the falsework, the additional force due to the concrete pipeline, F_x (in N), applied to the falsework may be calculated from the expression:

$$F_x = 0.25pA_x$$

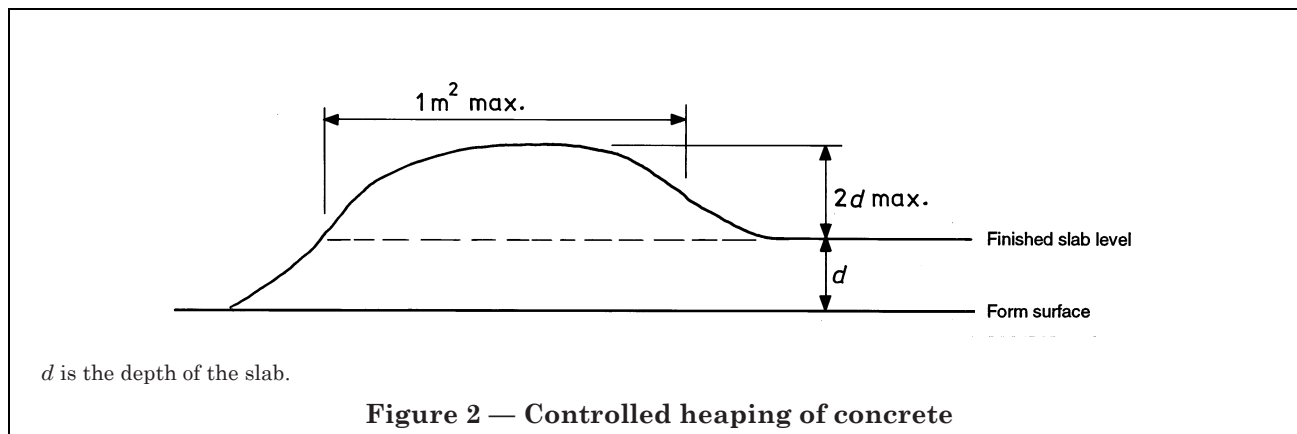
where

p is the maximum pressure in the pipeline (in N/mm²);

A_x is the cross-sectional area of the pipeline (in mm²).

The maximum pressure in the pipeline, p , is dependent upon a number of factors but the following pressures are not likely to be exceeded:

- 1) 5 N/mm², for mechanical pumps;
- 2) 0.7 N/mm², for pneumatic placers.



4.5 Environmental loads

4.5.1 Wind loading

4.5.1.1 General

The wind acts upon all surfaces over which it passes whether these are normal or inclined to the wind direction and may apply pressure or suction forces to those surfaces. The exposure of a falsework structure to wind produces different loading conditions for differing wind directions and speeds, at the various stages of falsework erection.

The basic data for the design of buildings to resist wind forces are contained in CP 3:Chapter V-2, which contains fundamental data concerning wind speeds and forces for different exposure conditions together with guidance on the application of this data to different building types and structures.

This code extracts from CP 3:Chapter V-2 the data needed to calculate wind forces on falsework structures.

4.5.1.2 Information required by the falsework designer

The following information is necessary for the calculation of wind forces:

- a) location of site;
- b) topography of site and exposure of the site to open wind conditions;
- c) duration of falsework operations and use;
- d) general arrangement of the structure, including its dimensions;
- e) numbers and sizes of falsework members from which to determine the areas on which the wind will act;
- f) details of the attachments to the falsework or items imposed upon it, e.g. formwork that will be subjected to wind forces.

4.5.1.3 Design wind speed, V_s

The assessment of wind speed should take into account the positioning and exposure of the falsework to the wind. The design wind speed is based upon the basic wind speed, V , appropriate to the district in which the falsework is to be erected. The basic wind speed is the 3 s gust speed estimated to be equalled or exceeded on the average once in 50 years. Values for V should be selected from Figure 3. The design wind speed, V_s (in m/s), is given by the expression:

$$V_s = VS_1S_2S_3$$

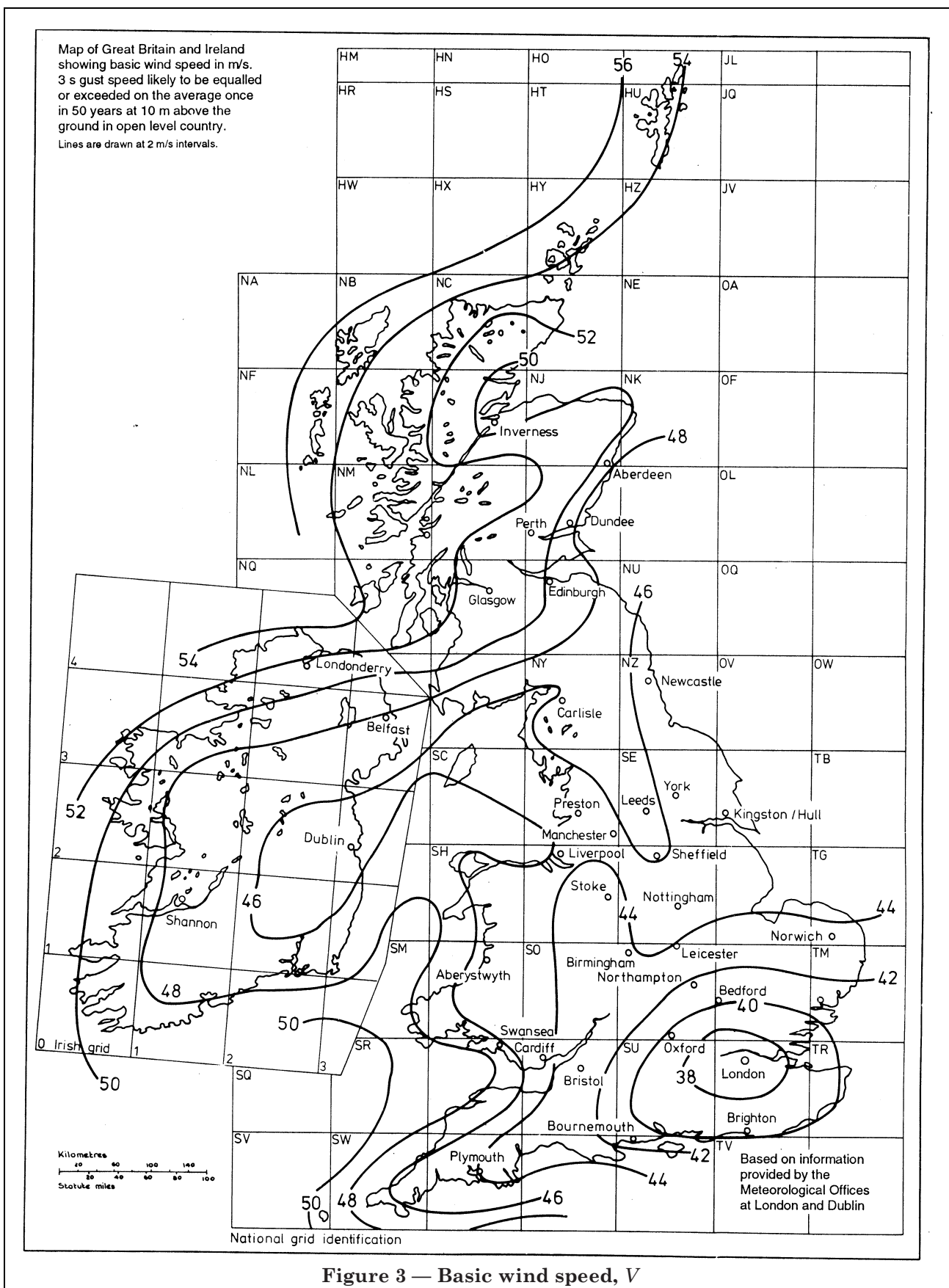
where

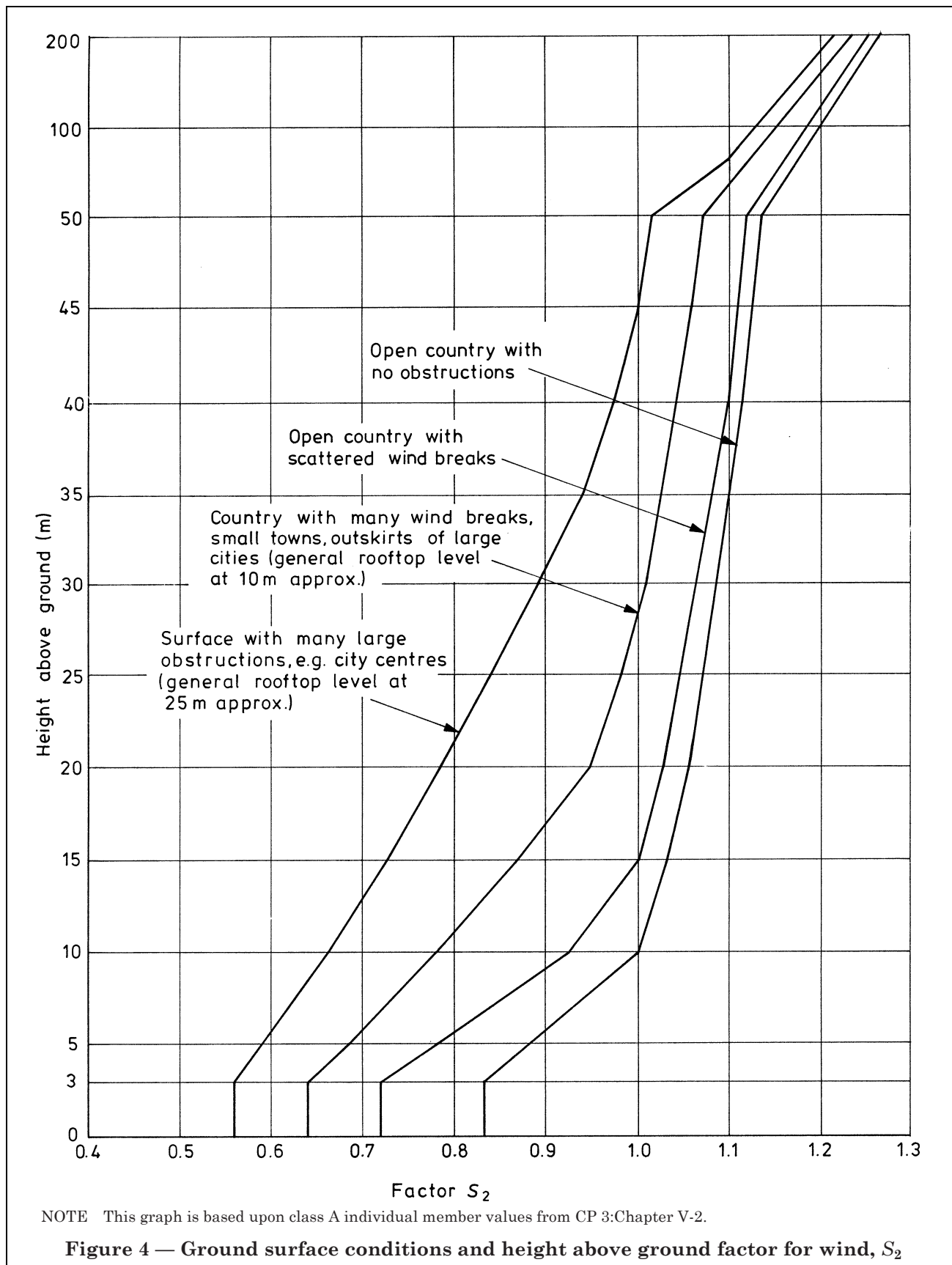
V is the basic wind speed (in m/s);

S_1 is the topography factor for wind (see 4.5.1.4);

S_2 is the ground surface conditions for height above ground factor for wind (see 4.5.1.5);

S_3 is the statistical factor (duration of exposure) for wind (see 4.5.1.6).





4.5.1.4 Topography factor for wind, S_1

Unless special topographical effects are present the value of S_1 should be taken as 1.0. In very exposed sites and some valleys that are so shaped that funnelling of the wind occurs with accelerated wind blowing up the valleys, a value for S_1 of 1.1 should be used. In steep-sided enclosed valleys sheltered from winds, wind speeds may be less than normal and a value for S_1 of 0.9 may be adopted. Caution should be used when applying the reduced factor of 0.9.

4.5.1.5 Ground surface conditions and height above ground factor for wind, S_2

The factor S_2 takes into account the effects of ground roughness and the variation of wind speed with height above the ground. Values of S_2 may be estimated from Figure 4.

The height should either be taken on the top of the structure or the height may be divided into convenient parts and the design wind speed calculated using a value of S_2 corresponding to the height above ground of the top of that part.

The height above ground should be above the general level that can be expected to influence air movement and not measured from the local platforms or hollows. Where the falsework is to be erected on or adjacent to a cliff or similar discontinuity, reference should be made to Annex D of CP 3:Chapter V-2:1972 for specific directions.

4.5.1.6 Statistical (duration of exposure) factor for wind, S_3

The factor S_3 is based on the risk of winds of a given severity occurring during a given period. It will be seen from Table 12 that the factor varies with the design life of the falsework, and increases as the design life of the structure increases. Since the maximum design wind speed has a low probability of occurrence with a short construction period, it is recommended that a value for factor S_3 of 0.77 be applied as appropriate for falsework being erected and used for less than two years. Other values of S_3 should be taken from Table 12. No value for S_3 below 0.77 should be used.

4.5.1.7 Dynamic wind pressure, q

Having calculated V_s , the dynamic wind pressure to be used in subsequent calculations should be obtained from Table 13.

The greatest dynamic wind pressures applicable for all falsework erected for a maximum of 2 years and not exceeding 30 m in height are:

- 1230 N/m², in England and Wales;
- 1670 N/m², anywhere in the United Kingdom.

These greatest dynamic wind pressures are calculated from the expression for V_s in 4.5.1.3, where:

V equals the highest basic wind speed in each of the areas;

S_1 equals 1.1 (very exposed site);

S_2 equals 1.1 (open country with no obstructions);

S_3 equals 0.77 (a two-year period).

Table 12 — Values of wind speed factor, S_3 (for probability level 0.63)

Life of the falsework years	Wind speed factor, S_3
Less than 2	0.77
2 to 5	0.83
5 to 10	0.88
over 10	1.00

Table 13 — Dynamic wind pressure, q , for various design wind speeds

Dynamic wind pressure q (in N/m ²), for a design wind speed, V_s (in m/s), of:										
V_{sa}	0 N/m ²	1.0 N/m ²	2.0 N/m ²	3.0 N/m ²	4.0 N/m ²	5.0 N/m ²	6.0 N/m ²	7.0 N/m ²	8.0 N/m ²	9.0 N/m ²
10	61	74	88	104	120	138	157	177	199	221
20	245	270	297	324	353	383	414	447	481	516
30	552	589	628	668	709	751	794	839	885	932
40	981	1 030	1 080	1 130	1 190	1 240	1 300	1 350	1 410	1 470
50	1 530	1 590	1 660	1 720	1 790	1 850	1 920	1 990	2 060	2 130
60	2 210	2 280	2 360	2 430	2 510	2 590	2 670	2 750	2 830	2 920
70	3 000									

^a Example. The dynamic wind pressure for a design wind speed of 46.0 m/s is 1 300 N/m².

4.5.1.8 Maximum wind force during life of falsework, W_m , on windward face

The maximum wind force during the life of the falsework, W_m (in N), acting on the windward face should be calculated from the expression:

$$W_m = qA_e C_f \eta$$

where

q is the dynamic wind pressure (in N/m²);

A_e is the effective frontal area of the member or frame normal to the wind direction (in m²) (see 4.5.1.9);

C_f is a force coefficient related to the shape of the member or frame subjected to wind action (see 4.5.1.10);

η is a shielding factor.

In the case of an unshielded windward face, η will have a value of 1. However, it is unrealistic to assume a full wind force on a falsework erected in an excavation or surrounded by walls as in basements or reservoirs, where the sides effectively shield it. Likewise, a falsework may be effectively shielded in some directions from a full wind force by abutments or already constructed walls. In such cases η should be taken as 0.5 and thus the calculated total wind force on the shielded part of the falsework and formwork may be reduced to one-half when considering the wind force in the shielded directions. 4.5.1.11 considers the effect of shielding on the force experienced by the inner members of the falsework structure.

The total wind force on the structure is the vectorial summation of the forces on the individual parts exposed to the wind. Attention is drawn to the circumstances dealt with in 4.5.1.13, which recognizes an upper limit to the generated wind force. The load may be assumed to be uniformly distributed over the area under consideration.

4.5.1.9 Effective area subject to wind forces

Since the wind can come from a number of directions, the most unfavourable load conditions should be taken. In most instances this will correspond to the wind acting in the direction normal to the surface of the member or frame.

The effective areas for the calculation of wind loads will comprise the shadow areas of:

- individual members, e.g. tubes, beams, props;
- frames, e.g. proprietary fabricated supports;
- formwork, e.g. beam sides, soffits, wall forms, together with supporting primary and secondary beams of the falsework;
- access ways, materials and plant carried by the falsework.

For square and triangular towers, the effective area is calculated for one face only (the force coefficients given in 4.5.1.10, to allow for the shielding of the leeward sides, are overall force coefficients for the towers for all wind directions).

Where the falsework is braced, the effective area of horizontal and vertical members should be increased by 20 % to allow for bracing and fittings, unless specifically measured.

4.5.1.10 Force coefficient, C_f , for falsework

The values of force coefficient, C_f , for falsework given in Table 14 apply to frames and towers where the geometric solidity ratio φ_w , which is the effective area of a frame (including bracing or bracing allowance) normal to the wind direction divided by the area enclosed by the boundary of the frame normal to the wind, lies between limits of 0.025 and 0.225. When this geometric solidity ratio is outside these limits, reference should be made to CP 3:Chapter V-2.

Table 14 — Force coefficient, C_f , for falsework

Item	Shape	C_f
Individual members	Flat sided and channel members	2.0
	Circular section	1.2
Single frame	Flat sided	1.8
	Circular section	1.2
Square lattice towers	Flat sided	3.7
	Circular section	2.2
Triangular lattice towers	Flat sided	3.0
	Circular section	1.7
Universal beams and columns		1.6

4.5.1.11 Shielding factor, η for falsework

The forces calculated in 4.5.1.8 give the full value of the wind force on the windward face of the structure. Should either the structure or a portion of it be sheltered from the full force of the wind, the values should be reduced by multiplying by a shielding factor, η .

Generally, for systems of adjustable props, framed towers and scaffolding as falsework, little shielding effect is obtained and $\eta = 1.0$.

Where there are multiple frames of similar geometry and spacing, and wind force on the third and subsequent frames should be taken as equal to that on the second frame. When summing the total wind force on the falsework structure comprising a large number of members in each direction there may be an upper limit to the wind force generated and guidance is given in 4.5.1.13.

In other cases the shielding factor, η should be obtained from Table 15 using the appropriate values of the spacing ratio and aerodynamic solidity ratio, β . The spacing ratio is equal to the distance, centre-to-centre, between frames, beams or girders measured parallel to the wind direction divided by the least overall dimension of those frames measured at right angles to the direction of the wind. The aerodynamic solidity ratio, β , is equal to the geometric solidity ratio φ_w (see 4.5.1.10), multiplied by a coefficient with a value of 1.6 for flat members, and 1.2 for circular and combinations of flat and circular members.

Table 15 — Shielding factor, η

Spacing ratio	Shielding factor, η , for an aerodynamic solidity ratio, β , of:							
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8 and over
Up to 1.0	1.0	0.96	0.90	0.80	0.68	0.54	0.44	0.37
Up to 2.0	1.0	0.97	0.91	0.82	0.71	0.58	0.49	0.43
Up to 3.0	1.0	0.97	0.92	0.84	0.74	0.63	0.54	0.48
Up to 4.0	1.0	0.98	0.93	0.86	0.77	0.67	0.59	0.54
Up to 5.0	1.0	0.98	0.94	0.88	0.80	0.71	0.64	0.60
Over 5.0	1.0	0.99	0.95	0.90	0.83	0.75	0.69	0.66

4.5.1.12 Wind forces on formwork and reinforcement

4.5.1.12.1 General

The falsework will usually be required to resist the loads caused by the wind acting on the formwork or other items the falsework is supporting. The formwork may comprise edge, beam, or wall forms with associated support members. In general, when calculating the wind force it is convenient to consider the force as having two components, the one acting on the soffit and its associated support work, i.e. blowing under the formwork, the other acting on the edge forms and the upper surface of beam or wall forms. These components may be calculated separately and combined, together with the calculated wind forces on the falsework itself, to give the total wind force on the whole structure (see 4.5.1.13).

Values for C_f , A_e , and η for use in the expression for W_m in 4.5.1.8 are given in 4.5.1.12.2 and 4.5.1.12.3. The value for q will be that appropriate to the site. For the purpose of this subclause, formwork sloping at a gradient of not more than 1 in 20 should be treated as being horizontal.

4.5.1.12.2 Wind forces on formwork prior to placement of concrete

a) *Soffit and support with wind blowing parallel to secondary beam (see Figure 5).* The wind forces on a soffit and its associated supporting beams where the wind is blowing parallel to the secondary beam should be calculated using the following values:

$$\begin{aligned} C_f &= 2.0 \\ \eta &= 1.0 \\ A_e &= d_1 L_f \end{aligned}$$

where

d_1 is the depth from the top of the soffit to the bottom of the primary beam measured normal to the soffit (in m);

L_f is the frontal length of the soffit measured normal to the wind (in m).

b) *Soffit and support work with wind blowing parallel to primary beams (see Figure 6).* The wind forces on a soffit and its associated supporting beams where the wind is blowing parallel to the primary beams should be calculated using the following values:

$$\begin{aligned} C_f &= 2.2 \\ \eta &= 1.0 \\ A_e &= d_2 L_f \end{aligned}$$

where

d_2 is the depth from the top of the soffit to the bottom of the secondary beam measured normal to the soffit (in m);

L_f is the frontal length of the soffit measured normal to the wind (in m).

The effect of wind on the ends of the primary beams may be ignored.

c) *Edge formwork with two forms [see Figure 7a)].* Where there are only two edge forms, the wind force on each edge form, considered above the general soffit level, should be calculated using the following values for C_f and A_e

$$\begin{aligned} C_f &= 1.8 \\ A_e &= d_1 L_f \end{aligned}$$

where

d_1 is the height of the edge form under consideration, measured normal to the soffit (in m);

L_f is the frontal length of the edge form measured normal to the wind (in m).

The value of η will vary according to the degree of shielding of the forms. For the windward form, with no shielding, η should be taken as 1.0. For any leeward edge form η will vary in accordance with the shielding effect of the windward edge form. The shielding effect is dependent upon the spacing, L_w (in m), of the two edge forms, A and D, as follows:

- 1) when $L_w \leq 3d_1$ $\eta = 0$;
- 2) when $L_w \geq 8d_1$ $\eta = 1$.

Intermediate values for η should be interpolated linearly between these limits.

Regardless of whether or not the windward and leeward forms are of dissimilar heights, only the height of the windward form need be used when assessing shielding effects.

d) *Edge formwork with more than two forms [see Figure 7b)].* For groups of more than two edge forms, the values for C_f and A_e should be taken as in item c). Where there are several groups of forms each group should be considered separately, e.g. in Figure 7b) there are four possible groups AB, BC, CD and AD and the shielding effect of spacings, $L_{w,1}$, $L_{w,2}$ and $L_{w,3}$, should be considered as for L_w in item c).

1) When estimating the extent of any shielding of form B, the values of $L_{w,1}$ and d_1 should be used for the calculation.

2) Where the distance $L_{w,3}$ is less than 1 m and/or where d_3 is less than $0.25d_4$, then the force on, and the shielding effect of, form C may be ignored, and the force on form D should be estimated for the group AD as in item c) (i.e. considering the shielding effect of d_1 and the spacing L_w). The value for C_f of 1.8 takes such instances into account.

e) *Combined beam and soffit formwork (see Figure 8).* Where the slab under construction incorporates beams, the wind force acting on such formwork should be calculated in a similar manner to that adopted for items c) and d), i.e. considering the forces on the side form faces and on the soffit and supporting beams as two separate items

1) Where the windward “beam 1” is an edge beam, or there is a length of slab cantilevering from it (see Figure 8a) and Figure 8b) respectively), the wind force on face A should be calculated using the following values:

$$C_f = 1.8$$

$$\eta = 1.0$$

$$A_e = d_1 L_f$$

where

d_1 is the overall depth from the top of the edge form to the underside of the beam (in m);

L_f is the frontal length of the formwork measured normal to the wind (in m).

The force on form B should be calculated as for item c).

2) In the case of “beam 2”, to the leeward of “beam 1”, if the distance $L_{w,4}$ is less than $6d_3$, the force on this beam may be ignored. Where $L_{w,4}$ is greater than $6d_3$, the wind force on E or F (see Note) should be calculated using the following values:

$$C_f = 1.8$$

$$\eta = 1.0$$

$$A_e = d_3 L_f$$

where

d_3 is the overall depth of the beam (in m);

L_f is the frontal length of the beam measured normal to the wind (in m)

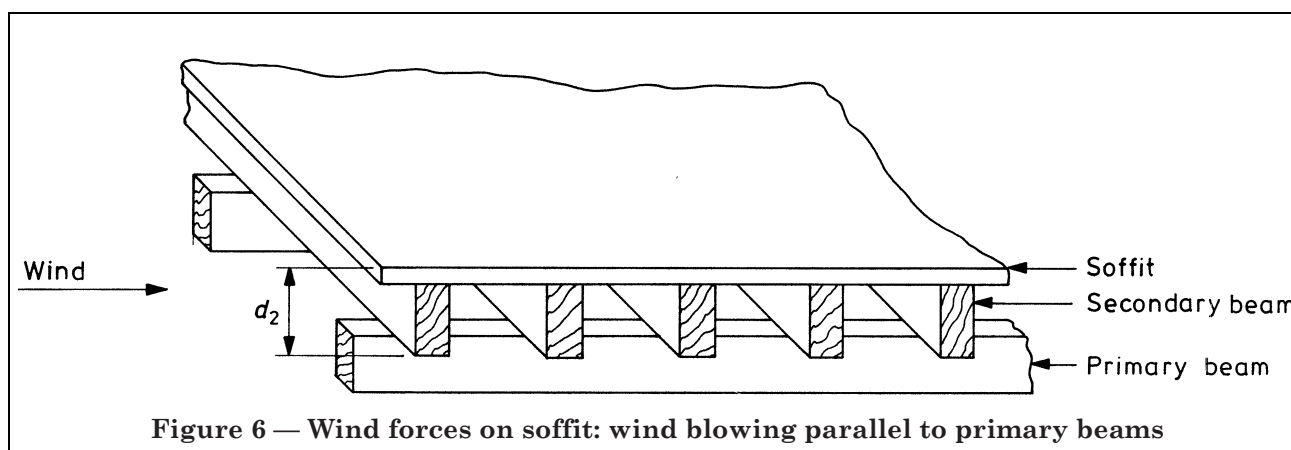
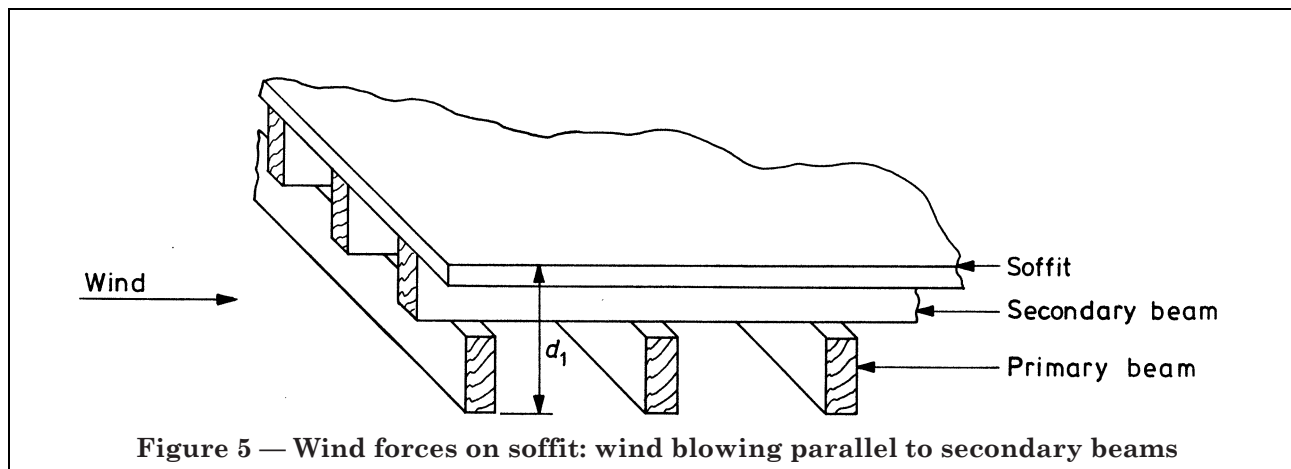
NOTE The wind will act on either side E or F according to whether the wind is travelling over or under the soffit, i.e. whether the beam forms are upstands (see Figure 8a)) or downstands (see Figure 8b)). The value of 1.8 for C_f takes into account any forces on the other side of beam 2.

3) For subsequent beams to the leeward of “beam 2”, the forces on each beam should be considered separately and in the manner recommended in item 2), taking $L_{w,4}$ as the distance between the beam in question and the adjacent windward beam.

4) The forces on the soffit and supporting beams should be calculated in accordance with items a) and b), as appropriate, and should be added to the values calculated in accordance with items 1) to 3) to obtain the total wind force on the combined beam and soffit formwork.

4.5.1.12.3 Wind forces on formwork after placement of concrete

The considerations in 4.5.1.12.2 apply prior to the placement of the concrete. Once concrete has been placed in the forms (as indicated by the dotted lines in Figure 7 and Figure 8) then the wind can be taken as acting on the outer forms only, and should be calculated as for 4.5.1.12.2 a), b) and c). The values for C_f take into account any negative pressure being developed on the downwind side of the leeward edge.



4.5.1.12.4 Wind force on reinforcement and completed sections of the permanent works

The wind forces on erected reinforcement may need to be considered should such reinforcement present a larger frontal area to the wind than the associated formwork. Where construction takes place on the formwork as a number of distinct concreting operations, the wind forces on the completed sections should be taken into account when considering the wind forces acting on the formwork and falsework.

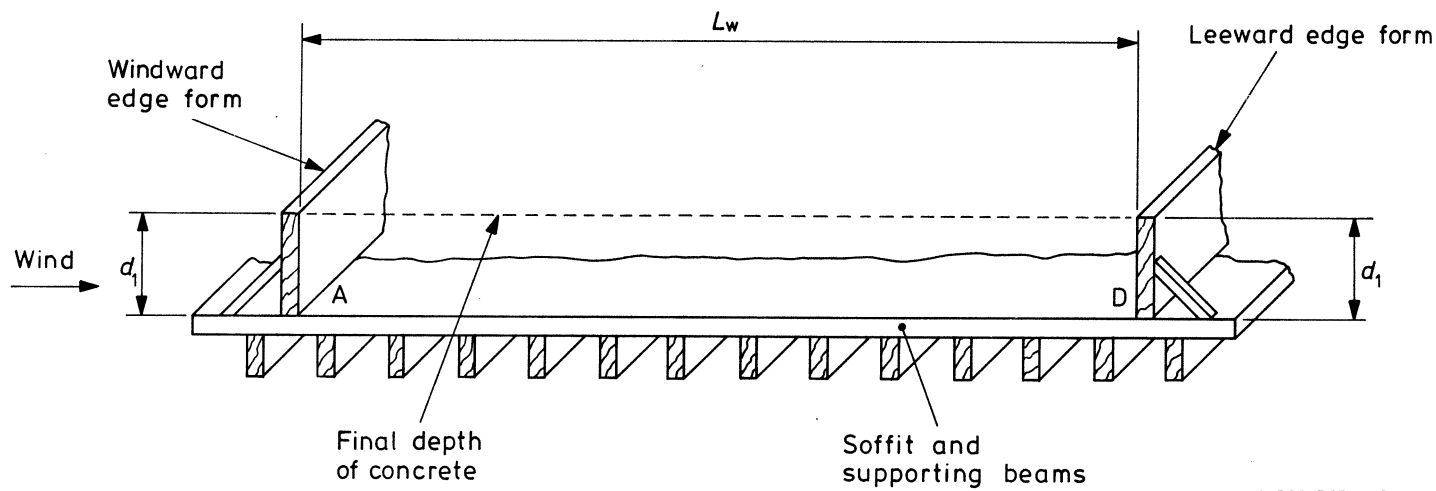
4.5.1.13 Upper limit to wind force

Providing the wind is constrained to pass through the falsework and does not escape up through the top of the falsework or laterally out through the sides, it has been shown by tests and calculations that the maximum wind force cannot exceed that calculated for a fully sheeted windward face to the falsework. Provided that these conditions are met, the falsework and associated formwork can be regarded as a notional continuous impermeable face. The actual maximum wind force will not exceed the value of the area of this notional impermeable face multiplied by a value of $1.2q$, with a centroid of such a force at the height of $0.5(h_f + h_F)$ above the founding level (see Figure 9).

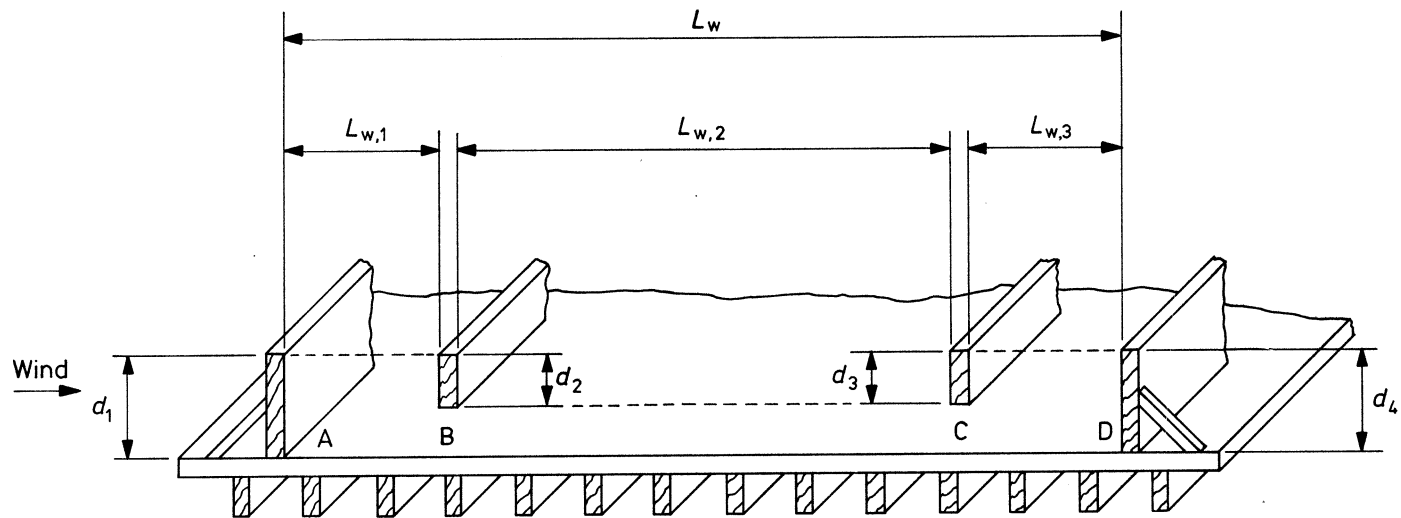
where

- q is the dynamic wind pressure (in N/m^2);
- h_f is the windward height of formwork (in m);
- h_F is the windward height of falsework (in m).

To this calculated force on this notional windward impermeable face should be added the loads generated on downstream parapets or similar caused by the wind crossing over the top of the assembly. This total force should be compared with that force calculated in accordance with 4.5.1.3 to 4.5.1.12 and the lower value used for the design of the falsework for those wind conditions.



a) Two forms



b) More than two forms

Figure 7 — Wind forces on edge formwork