

Water cooling towers —

Part 4: Code of practice for structural design and construction

ICS 27.100:91.080

Confirmed December 2011

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/525/15, Cooling towers, upon which the following bodies were represented:

- Association of Consulting Engineers
- BEAMA Ltd.
- Concrete Society
- Electricity Association
- Engineering Employers' Federation
- Federation of Civil Engineering Contractors
- Health and Safety Executive
- Hevac Association
- Industrial Water Society
- Institution of Chemical Engineers
- Institution of Civil Engineers
- Institution of Structural Engineers
- Process Plant Association
- Co-opted member

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on 15 August 1996

© BSI 07-1999

The following BSI references relate to the work on this standard:
Committee reference B/525/15
Draft for comment 92/17117 DC

ISBN 0 580 25544 1

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
Section 1. General	
1.1 Scope	1
1.2 References	1
1.3 Definitions	1
1.4 Symbols	3
1.5 Materials and workmanship	3
1.6 Packing support structures	6
1.7 Packings, water distribution systems, eliminators and cladding	8
1.8 Cooling tower fittings	9
1.9 Water retaining structures	9
1.10 Foundations and bases	10
Section 2. Hyperboloidal cooling towers (type 1 towers)	
2.1 Basis of design	11
2.2 Loading	11
2.3 Design considerations	12
2.4 Construction	18
Section 3. Mechanical draught towers (type 2 towers)	
3.1 Characteristic loads	20
3.2 Design considerations	20
Annex A (normative) Recommendations for stress graded timber triangular section laths	21
Annex B (normative) Guidance on the use of plastics materials	23
Annex C (informative) Wind tunnel testing	24
Annex D (informative) Circumferential wind pressure distribution for hyperboloidal towers	24
Annex E (normative) Estimation of resonant stresses	24
Annex F (informative) Derivation of natural frequencies of hyperboloidal towers	25
Figure 1 — Pressure coefficient distribution for determination of wind loading	13
Figure 2 — Arrangement of reinforcement trimming for openings in shells	17
Figure 3 — Arrangement of reinforcement in the shell	18
Figure A.1 — Splay knot	22
Figure A.2 — Arris knot	22
Figure A.3 — Face knot	22
Figure F.1 — Typical finite element representation of cooling tower with column supports	26
Table 1 — Dimensional deviations of precast components	4
Table 2 — Coatings of metal components	7
Table 3 — Determination of λ_θ and λ_φ	15
Table 4 — Correction factors for stresses due to adjacent structures	16
Table 5 — Minimum reinforcement in shell	16
Table A.1 — Permissible knot size for a 38 mm × 38 mm lath	21
List of references	27

Foreword

This Part of BS 4485, which has been prepared by Subcommittee B/525/15, Cooling towers, is concerned with the structural design and construction of natural draught and mechanical draught cooling towers. It is a revision of BS 4485-4:1975, which is now withdrawn.

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 Part of BS 4485 contains three sections: a general section relating to all towers and two separate sections covering hyperboloidal shell natural draught towers and mechanical draught towers.

The method of design of concrete shells of natural draught towers has been the subject of extensive changes. This edition differs from the previous 1975 edition as follows.

- a) Wind loadings are based on hourly mean winds, as derived in BS 6399-2.
- b) An amplification factor to the wind loading is introduced to take account of the fluctuations in incident wind on the tower, and the effect on resulting stresses of tower resonant response in the incident wind. The factor is derived by an empirical equation, related to design wind speed and the natural frequency of the tower. It is derived from wind tunnel test results.
- c) Serviceability limit states are defined more fully and include an additional equation for buckling of the shell, and limitations to which uplift of foundations may be permitted under factored wind loading.
- d) Design is related to BS 8110, including the shell support system.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations. In particular, attention is drawn to the Reservoirs Act 1975 [1] and the need to ascertain at the time of the design of the cooling tower systems whether or not the cold water basin, especially if connected to other towers, comes within its scope.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 28, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope

This Part of BS 4485 gives recommendations for the structural design and construction of water cooling towers of the following types:

- a) type 1. Natural draught or assisted draught towers, in which the total air flow is wholly or partly induced by a reinforced concrete shell of hyperboloidal form;
- b) type 2. Mechanical draught towers, in which the total air flow is induced wholly by mechanical means within an enclosed structure.

It applies only to those cooling towers constructed or erected on site and excludes factory assembled towers. In addition, matters relating to construction and workmanship in concrete and other materials are dealt with only in so far as they are specific to cooling tower construction. Other items of construction are referred to in appropriate specifications.

This code of practice covers the design of towers up to 170 m in height. However certain restrictions apply to formulae used for towers greater than 120 m in height.

NOTE For cooling towers of type 1, shells similar in shape to the true hyperboloidal form may be considered. Where these other shapes are adopted then certain sections of this standard may not be strictly applicable.

1.2 References

1.2.1 Normative references

This Part of BS 4485 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 27 and 28. For dated references, only the edition cited applies: any subsequent amendments to, or revisions of the cited publication apply to this Part of BS 4485 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This Part of BS 4485 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 28, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this British Standard the definitions in BS 6100-4 apply together with the following.

1.3.1

air flow

total quantity of air including associated water vapour flowing through the tower

1.3.2

arris knot

knot which emerges on an arris (see Figure 5)

1.3.3

basin kerb

top level of the retaining wall of the cold water basin

NOTE 1 Usually the datum point from which tower elevation points are measured.

NOTE 2 Basin kerb is also known as pond sill.

1.3.4

cell height

distance from the basin kerb to the top of the fan deck, but not including the fan stack

1.3.5

cell length

dimension parallel to the inlet louvred face

1.3.6

cell width

dimension at right angles to the cell length

1.3.7

circulating water flow

quantity of hot water which flows into the tower

1.3.8

coarse screen

grill located at the outlet of the cold water basin which retains large debris and prevents it from entering mechanical plant or pipework

1.3.9

cold water basin

device that underlies the tower to receive cooled water from the packing

NOTE Cold water basin is also known as basin or pond.

1.3.10

column anchor

device that attaches the tower structure to the foundation; it does not include the foundation bolt

1.3.11

distribution basin

elevated basin which distributes hot water over the tower packing

**1.3.12
distribution header**

pipe or flume which delivers water from the inlet connection to lateral headers, troughs, flumes or distribution basins

**1.3.13
distribution system**

those parts of a tower, beginning with the inlet connection, which distribute the hot circulating water throughout the tower to the point where it contacts the air

**1.3.14
drift eliminator**

system of baffles within the tower which reduces the quantity of entrained droplets of water in the outlet air

**1.3.15
face knot**

knot on a face, other than a splay or arris knot (see Figure 6)

**1.3.16
film packing**

arrangement of surfaces over which the water flows in a continuous film throughout the depth of the packing

**1.3.17
louvres**

- 1) Members installed in the wall of a type 2 tower or at the entry to a cross flow packing, which direct air flow into the tower and reduce blow-out of water from the tower.
- 2) Individual units forming the baffles of a drift eliminator.

**1.3.18
nominal tower dimensions**

dimensions used to indicate the effective size of cells or cooling tower. In the horizontal plane these are the approximate width and length of packed areas, and in the vertical plane the height above the basin kerb level

**1.3.19
packing**

material placed within the tower to increase heat and mass transfer between the circulating water and the air flowing through the tower

NOTE Packing is also known as pack or filling.

**1.3.20
packing support structure**

structure of beams and columns, generally in timber or concrete, which support the packing, distribution pipework or flumes and drift eliminator

**1.3.21
ringbeam**

thickened, lowermost part of the shell immediately surmounting the shell support columns, spanning the column heads

NOTE Ringbeam is also known as lintel.

**1.3.22
shell**

part of a type 1 tower which induces air flow

**1.3.23
shell support column**

inclined column or wall which spans the air intake opening and transmits the dead load of the shell, and any forces induced in it, to the foundation

NOTE Shell support column is also known as leg.

**1.3.24
shell support node**

junction between a pair of shell support columns and the ring beam

**1.3.25
splash bar**

a small section lath, generally of rectangular or triangular cross section, located in a splash packing to initiate the formation of droplets

**1.3.26
splash packing**

arrangement of horizontal laths or splash bars which promotes droplet formation in water falling through the packing

**1.3.27
splay knot**

knot cut more or less parallel to its long axis so that the exposed section is elongated

NOTE On triangular laths the length of the knot will frequently extend across the width of the face.

**1.3.28
spray nozzle**

device which dispenses cooling water from the distribution pipework so that it is uniformly distributed over the packing

**1.3.29
spray nozzle adaptor**

device incorporated in the distribution pipework which easily or securely fixes the spray nozzle in position

**1.3.30
sump**

lowered portion of the cold water basin floor for draining

NOTE Sump is also known as basin sump or pond sump.

1.3.31**water loading**

circulating water flow expressed in quantity per unit plan area of the packing

1.4 Symbols

For the purposes of this Part of BS 4485 the following symbols apply.

A_φ	area of reinforcement
C_D	dynamic correction factor
C_G	grouping correction factor
$C_{P,\theta}$	pressure coefficient at angle θ from incident wind direction
E	static modulus of elasticity
f_y	steel characteristic strength
G_k	characteristic dead load
H	height of tower
h	shell thickness
K	empirical factor (described in Annex E)
k	dynamic wind pressure constant
N_φ	meridional stress resultant
$N_{\varphi,g}$	gust stress resultant at design gust speed
$N_{\varphi,m}$	mean stress resultant at hourly mean wind speed
$N_{\varphi,r}$	stress resultant from resonance of the shell due to wind turbulence
$N_{\varphi,\theta}$	absolute value of shear stress resultant
n	lowest natural frequency of tower
q_{cr}	critical dynamic wind pressure
q_g	dynamic gust wind pressure at throat
$q_{g,z}$	dynamic wind pressure at design gust speed
$q_{m,z}$	dynamic wind pressure at design mean wind speed
q_z	dynamic wind pressure at height z
R_B	radius at underside of ring beam
R_T	throat radius
S_c	fetch factor
S_d	direction factor
$S_{g,z}$	gust wind speed factor
S_h	topographic increment
$S_{m,z}$	hourly mean wind speed factor
S_t	turbulence factor
T_c	fetch adjustment factor

T_t	turbulence adjustment factor
$V_{g,z}$	design gust speed at height z
$V_{m,z}$	design mean wind speed at height z
V_s	site wind speed
V_z	wind speed at height z
W_k	characteristic hourly mean wind load
z	height above ground
Z_T	height of throat above underside of ring beam
θ	angular position measured from the incident wind direction
$\varphi I, \varphi G, \varphi F$	amplification factors for stress resultants
σ_θ	circumferential compressive membrane stress
σ_φ	meridional compressive membrane stress
$\sigma_{\theta,cr}$	circumferential critical buckling stress
$\sigma_{\varphi,cr}$	meridional critical buckling stress
γ_B	factor of safety against buckling
ν	Poisson's ratio

1.5 Materials and workmanship**1.5.1 Concrete****1.5.1.1 General**

The concrete should be a designed mix conforming to BS 8110-1, subject to the recommendations in 1.5.1.2 to 1.5.1.5.

1.5.1.2 Cement

Cement should conform to BS 12 or BS 4027.

1.5.1.3 Pulverized fuel ash (PFA)

Pulverized fuel ash should conform to BS 3892-1 and should be used in accordance with 3.3.5, 6.1.2 and 6.2.4 of BS 8110-1:1985.

1.5.1.4 Aggregates

Fine and coarse aggregates from natural sources, which conform to BS 882, should be used.

Particular attention should be given to the selection of dense aggregates of low drying shrinkage, in order to reduce adverse effects on strength, density, shrinkage, moisture movement, frost resistance or durability of the concrete.

In cooling tower shells the maximum size of aggregates should not exceed $C-5$ mm where C is the nominal specified cover to the reinforcement.

1.5.1.5 Admixtures

If admixtures are used they should conform to BS 5075. Appropriate production control measures should be applied to their use.

1.5.2 Reinforcement

Reinforcement to concrete should conform to clause 7 of BS 8110-1:1985.

1.5.3 Prestressing tendons

Prestressing tendons should conform to clause 8 of BS 8110-1:1985.

1.5.4 Precast concrete

1.5.4.1 Materials

The materials used in the manufacture of precast concrete components should conform to 1.5.1, 1.5.2 and 1.5.3.

1.5.4.2 Workmanship

1.5.4.2.1 Precast components which form part of the packing support structure should be manufactured within the dimensional tolerances specified in 6.11 of BS 8110-1:1985 except that the variations given in Table 1 should apply.

Table 1 — Dimensional deviations of precast components

Length of component m	Straightness of bow (deviation from intended line) mm
< 6	6
6 to 12	9
Add for each subsequent 6 m	3

1.5.4.2.2 Except as stated in 1.5.4.2.3 to 1.5.4.2.5, the nominal cover to precast components, other than in the shell, should be in accordance with 3.3 of BS 8110-1:1985, where the exposure condition in service, as described in Table 3.2 of BS 8110-1:1985, should be regarded as severe.

1.5.4.2.3 When precast components are used in the shell, nominal cover to all reinforcement should be not less than 30 mm.

1.5.4.2.4 If the components of the packing support structure are situated in the airflow and it is necessary to minimize obstruction to the airflow, the nominal cover may be less than the value given in 1.5.4.2.2, but not less than 25 mm. The tolerance on this reduced cover should be $^{+3}_0$ mm.

1.5.4.2.5 If the airflow or circulating water contains an aggressive constituent(s), especially if industrial waste products are discharged, the cover in 1.5.4.2.2 and 1.5.4.2.3 should be increased by an amount appropriate for the anticipated operating conditions; it should be not less than that specified for the service conditions described as very severe, as given in Table 3.2 of BS 8110-1:1985. This also applies to any treatment which might be applied to the circulating water flow as a means of controlling algal growth, scaling and the like.

1.5.4.3 Erection

1.5.4.3.1 Lifting hooks and eyes for the lifting and erection of precast components should be removable.

1.5.4.3.2 Cast-in fittings should be in accordance with 1.5.11, except when fabricated from low carbon steel they should be protected in accordance with 1.5.12.

1.5.4.3.3 If jointing of precast components results in bolt heads being recessed in pockets then such pockets or other similar cavities should be filled with bitumen after erection.

1.5.4.3.4 Mating surfaces of precast components, crossed by a fixing bolt, should be treated with a coat of polymer modified hydraulic cement mortar, epoxy mortar, bitumen or similar material to protect the bolt from ingress of water.

1.5.5 Reinforced concrete

1.5.5.1 The materials used in the manufacture of reinforced concrete should conform to 1.5.1 and 1.5.2.

1.5.5.2 Reinforced concrete should conform to BS 8110 and/or BS 8007 as appropriate, except for the recommendations given in 1.5.5.3 to 1.5.5.8.

1.5.5.3 Concrete in the shell should have a characteristic strength sufficient to withstand the temporary loadings that will be imposed upon it but not less than 40 N/mm² at 28 days.

1.5.5.4 The supervision, setting out, checking and shuttering system should achieve a high degree of dimensional accuracy in accordance with 1.5.5.5 to 1.5.5.8.

1.5.5.5 The thickness of the finished concrete in the shell should not vary from the design thickness by more than ± 6 mm.

1.5.5.6 The interior surface of the shell should not vary from its stipulated position by more than ± 40 mm. In addition, the measured offset from any 3 m chord should not differ from the theoretical offset by more than ± 10 mm.

1.5.5.7 In the line of the shell in the vertical plane, the shell should not change direction, other than to form the curve of the tower, by more than 10 mm in any 1 m of slant height.

1.5.5.8 The shell should be surveyed at the appropriate level after the completion of each lift. Readings should be taken in at least one position on each primary formwork unit.

1.5.6 Prestressed concrete

1.5.6.1 Materials

The materials used in the manufacture of prestressed concrete should conform to **1.5.1**, **1.5.2** and **1.5.3**.

1.5.6.2 Workmanship

Prestressed concrete should conform to BS 8110. Where members are precast the recommendations of **1.5.4.2** should apply.

1.5.7 Timber

1.5.7.1 Structural softwoods should be in accordance with BS 4978:1988 and should normally be limited to the species stated in Table 9 of BS 5589:1989. Due care should be taken to select softwoods which are amenable to preservatives.

1.5.7.2 Hardwoods should be in accordance with BS 5756:1980.

1.5.7.3 Timber splash bars, which form the packing, will normally be of Redwood (*Pinus silvestris*). If other timbers, such as Douglass fir (*Pseudotsuga menziesii*) are offered, then the performance of such timber, when cut to the required cross-section and treated in accordance with **1.5.8**, should be comparable to or superior to that of Redwood. In all cases, timber used for splash bars should meet the visual stress grading recommendations of Annex A.

1.5.7.4 Other timber members, with a minimum dimension of less than 75 mm, such as eliminator louvres, air sealing barrier walls, doors and door frames, trap door walkways and handrails, should conform to the recommendations of **1.5.7.3**.

NOTE The recommendations for timber laths given in Annex A do not apply to the members covered by this sub-clause.

1.5.7.5 For the design of structure members (excluding damboards, see **1.8.2**) the stress and load values of suitable timbers, taking into account wet exposure conditions, should be in accordance with BS 5268-2.

NOTE Temperatures of up to 60 °C in cooling towers are not considered to affect timber strengths significantly. For applications above this temperature, specialist advice should be sought on permissible timber strength properties for design.

1.5.7.6 All softwoods should be treated against wood-destroying organisms in accordance with **1.5.8**.

1.5.8 Timber preservation

1.5.8.1 Softwoods should be treated against wood destroying organisms using suitable preservatives and methods of treatment in accordance with BS 5589 (with particular reference to Sections 4 and 5).

1.5.8.2 Preservative treatment should be checked in accordance with clause 9 of BS 5589:1989.

1.5.9 Asbestos-cement materials

Alternative fibres to asbestos are recommended for items used in cooling towers.

NOTE Attention is drawn to the regulations that are in force governing the cutting and installation of asbestos based materials, and the guidance notes issued by the Health and Safety Executive, particularly if any replacement or repair is necessary [2].

Asbestos-cement sheets and boards used in cooling towers should be in accordance with BS 690 except as follows.

If non-standard board is used, owing to size or fittings requirements, the sheets should be marked as being outside the range of BS 690.

Packings are normally specially manufactured and, whilst they should be generally in accordance with BS 690, the type of fibre and sheet dimensions may be varied.

1.5.10 Plastics

NOTE Guidance on the properties and use of plastics in cooling towers is given in Annex B.

1.5.10.1 Glass reinforced plastics fabrications, for use in cooling tower applications, should be to marine grade specification using “E” glass fibre reinforcement as chopped strand mat, rovings or fabric (BS 3496, BS 3691 and BS 3749). A gel coat finish should be applied to the inside face of any moulding to ensure that the glass fibres are protected by a resin coat without pinholes or holidays.

1.5.10.2 Mouldings should be free from voids or areas of poor wetting-out of glass fibre reinforcement.

NOTE Such defects can lead to “osmosis” generally manifested by the appearance of bubbles on the surface in contact with the water.

1.5.10.3 External cladding in extruded plastics should be treated against UV degradation. To avoid undue risk of biological slime or algae forming on the inside faces of cladding, the cladding materials should be relatively opaque.

1.5.10.4 Reference should be made to plastics manufacturers’ recommendations for temperature and chemical resistance values on all plastics materials.

1.5.11 Metalwork

1.5.11.1 The choice of materials used for sundry metalwork fittings should take account of the damp, warm atmosphere within the tower and the corrosive effect of chemicals in the water. If the materials used are not resistant to such conditions a suitable protective coating should be applied in accordance with 1.5.12.

1.5.11.2 Cast iron for large fittings should be in accordance with BS 1452.

1.5.11.3 Malleable cast iron for small fittings should be in accordance with BS 6681.

1.5.11.4 Stainless steel should be in accordance with BS 1501, BS EN 10028-1 and BS EN 10029.

1.5.11.5 One of the following aluminium alloys: 1200 (SIC), 3103 (N S3), 5154 A (N S5) and 6082 (HS 30) should be used, conforming to BS 1470. Sheets used for fabrication should be not less than 1.6 mm thick.

If the water has a pH less than 6 or greater than 8.5 protection should be provided by anodizing or other processes.

Design stresses should be in accordance with BS 8118.

Aluminium is anodic to other materials and when joined to such materials electrolytic action can occur. Measures should be taken to prevent direct contact between aluminium and other metals.

1.5.11.6 Other metals and alloys should be used in accordance with British Standards.

1.5.11.7 Different metals/alloys should not be placed in contact with each other if there is a possibility of electrolytic action between them causing corrosion.

NOTE Attention is drawn to the possibility of stress corrosion occurring in stainless steel particularly where halides may be present.

1.5.12 Protective coatings and paint

1.5.12.1 In general materials that require no protective coating should be chosen so that maximum service life without repair or replacement is possible.

1.5.12.2 As a minimum protection, coatings should be applied as given in Table 2.

1.5.12.3 Bolts should have a coating of bitumen applied after assembly to protect areas of the threads where the original coating may have been damaged.

1.5.12.4 Epoxy resin paint, chloroprene rubber or other suitable painting systems may be used to give a protection not less than those given in Table 2. Material should be applied in accordance with BS 5493.

1.5.13 Adhesives

Where adhesives are used in cooling towers, the manufacturers should be fully informed of the working conditions and their advice should be carefully followed in respect of the conditions and method of application.

1.5.14 Pipework

1.5.14.1 Asbestos-cement pipework should be manufactured and installed in accordance with BS 3656. If operating and/or surge pressures in the distribution system are in excess of those which can be tolerated by pipework to this standard, then pipework should be in accordance with BS EN 512.

1.5.14.2 Thermoplastic pipework should be manufactured in accordance with BS 5556 and installed in accordance with the manufacturer's recommendations.

1.5.14.3 Glass fibre reinforced plastics (GRP) pipework should be designed, manufactured and tested in accordance with BS 5480.

1.5.14.4 Precast concrete pipes should be manufactured and tested in accordance with BS 5911-110.

1.5.14.5 Precast concrete pipes of glass composite construction should conform to BS 5911-101 and those reinforced by chopped, zinc coated, steel fibres should be installed and tested in accordance with the manufacturer's instructions.

NOTE DD 76-2 may be referred to also.

1.6 Packing support structures

1.6.1 General

Packing support structures should be designed and constructed to facilitate examination and maintenance.

1.6.2 Design

1.6.2.1 Structural considerations

1.6.2.1.1 Loadings

The following loadings should be considered:

- self weight;
- supported packing load, including water and accumulations of scale, silt, etc.;
- wind;
- ice (weight and the effect of wind on the ice sheet);
- maintenance loads with a minimum vertical load of 1.5 kN at any position.

NOTE In many cases it will be found that the most severe loading condition occurs during transport or erection.

Table 2 — Coatings of metal components

Type of metal	Coating	British Standard	Grade
Steel	Electroplated zinc ^a	BS 1706	Zn3
	Electroplated cadmium ^a	BS 1706	Cd3
	Hot dip galvanized	BS 729	NA
	Sherardized	BS 4921	Class 2
	Electroplated nickel	BS 1224	Medium application grade
	Electroplated nickel and chromium	BS 1224	Service condition no. 2
Copper or brass	Electroplated nickel	BS 1224	Medium application grade
	Electroplated nickel and chromium	BS 1224	Service condition no. 2
Aluminium	Anodized	BS 1615	AA10
Aluminium alloy	Electroplated nickel	BS 1224	Medium application grade
	Electroplated nickel and chromium	BS 1224	Service condition no. 2
Screw threads	Any of the above coatings covered by BS 3382	BS 3382	NA

NOTE 1 Where tolerances are important it is recommended that the manufacturer should also specify a maximum coating thickness (which should be not less than twice the minimum thickness).

NOTE 2 Attention is drawn to the clauses concerning hydrogen embrittlement in the relevant standards. The plater should be informed of the specification of the steel to be plated.

NOTE 3 The cleaning and preparation of parts before coating should be carried out to the highest standard (see BS 773:1995).

^a Denotes preferred finishes. Zinc coatings are more suitable for general use including use in industrial atmospheres, and cadmium is more suitable for use in marine environments.

1.6.2.1.2 Stability

The structure itself and any other structure that could limit gross distortion should be designed to resist collapse under a horizontal acceleration of 0.02g. Special care should be taken to ensure that the structure is adequately braced in all directions at all stages of construction.

1.6.2.2 Timber members

The design of timber members should be in accordance with BS 5268-2.

1.6.2.3 Concrete members

The design of concrete members should conform to BS 8110 except for the recommendations in 1.5.4.2. Due attention should be given to the overall movements of the structure under the effects of temperature, shrinkage, creep and imposed loading; particularly if restraint is present.

1.6.3 Construction

1.6.3.1 Timber

1.6.3.1.1 All timber members should be factory cut, drilled, treated with preservative and delivered to site ready for erection.

1.6.3.1.2 Preservation of the timber members should be carried out in accordance with 1.5.8 after jointing, cutting and drilling. No timber should be ripped along the grain after treatment. Any timber cross-cut or drilled after treatment should have the cut surfaces protected by a liberal brush application of a suitable cut-end preservative.

1.6.3.1.3 The work should be carefully supervised to ensure the inclusion of all connectors and shear plates, especially those which are not visible in the completed structure.

1.6.3.2 Concrete

1.6.3.2.1 The reduced cover permitted in 1.5.4.2 for precast concrete members should not be used for cast in-situ concrete.

1.6.3.2.2 Joints may be bolted, dowelled, or cast in-situ. Bolts or dowels used for permanent connections should be of a material highly resistant to corrosion or fully protected by embedment or coating.

1.6.3.2.3 Erection tolerances should conform to BS 5606.