

Specification for

The use of structural steel in building —

Part 2: Metric units

**BS 449-2:
1969**

*Incorporating
amendments issued
January 1970
(AMD 416), May 1970
(AMD 523), December
1970 (AMD 661),
April 1973 (AMD
1135), July 1975
(AMD 1787), August
1984 (AMD 4576),
May 1988 (AMD
5698), December 1989
(AMD 6255) and
Amendment No. 9*

UDC 693.814:624.016.7:669.14.018.29

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 Ministry of Public Building and Works
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 National Federation of Building Trades Employers
 Royal Institute of British Architects
 The Welding Institute

This British Standard, having been approved by the Building Divisional Council and the Council for Codes of Practice, was published under the authority of the Executive Board on 31st October, 1969

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First published, April, 1932
 First revision, December, 1935
 Second revision, July, 1937
 Third revision, July, 1948
 Fourth revision (incorporating CP 113), May, 1959
 Reset and reprinted, February, 1965
 Reprinted in October, 1967
 BS 449-2, metric edition of revision, published October, 1969

The following BSI references relate to the work on this standard:
 Committee reference B/20
 Draft for approval 69/239

Amendments issued since publication

Amd. No.	Date of issue	Comments
8859	November 1995	Indicated by a sideline in the margin

ISBN 580 05523 X

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Foreword

BS 449 was first issued in 1932 and was revised in December 1935, July 1937, July 1948 and May 1959. It was reset and reprinted in February 1965 incorporating amendments Nos. 1 to 5 and reprinted in October 1967 incorporating amendments Nos. 6 and 7.

When a programme of Codes of Practice for Buildings was drawn up in 1942 under the aegis of the Ministry of Works, a Code of Practice for the structural use of steel in buildings was included in a series for all types of building construction: this was later (1948) issued as CP 113. Much of the information given in BS 449 and in CP 113 was the same and with the formation of the Codes of Practice Council within BSI it was decided that the two documents should be amalgamated and issued as a single publication under the main reference BS 449.

Part 2 of this standard has been prepared, in accordance with the change to the metric system in the construction industry, giving values in terms of SI units. For further information on SI units, reference should be made to BS 3763, "International System (SI) units" and PD 5686, "The use of SI units".

The values given in Part 2 represent the equivalents of the values in imperial units in BS 449:1959, rounded to convenient numbers. Although the values are not exact equivalents of the imperial ones, Part 2 does not constitute a technical revision of the standard and is substantially similar in content to BS 449:1959.

Amendment Slip No. 8 (AMD 94) published 12th September, 1968 introduced into this standard the use of steels complying to BS 4360, "Weldable structural steels" superseding the requirements of BS 15, BS 968 and BS 2762. This amendment slip also noted the future insertion of grade 55 steel. Part 2 has now been expanded to include the use of this steel, and also includes an amendment to Subclause 3 a). Amendment Slip No. 6 (PD 5854) published 29th June, 1966 revised Subclause 3 a) and introduced into this standard, precautions against brittle fracture. This subclause on brittle fracture has now been further extended to be in parity with BS 4360. Because of the extent of the amendments made necessary by the publication of BS 4360 it has been found more practical to reissue the imperial edition of this standard incorporating these amendments rather than to publish a further amendment slip.

For the purpose of compliance with this standard designers may use the values given in either BS 449:1959 or this part, provided that one set of values is used consistently throughout the design of each part of a structure.

A revision of this standard is currently in hand and the revised standard will be written in terms of SI units only.

Users of this British Standard should satisfy themselves that effective compliance is secured with local bye-laws and regulations and, for insurance purposes, with any requirements of insurance companies.

The attention of users is also called to the importance of making provision, where necessary, for water, gas, electricity and other services, having particular regard to condition 5 in Clause 21 for cased beams and to condition 4 in Subclause 30 b) for cased struts.

This standard reflects the revised increased yield strength of grade 43 steels included in BS 4360.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared, and that construction and supervision is carried out by capable and experienced organizations.

Economy in design

This British Standard stipulates limits of stress and gives rules for design, with the twofold purpose of ensuring normal safety and economy in the use of structural steel. While the stresses and other requirements are to be regarded as limiting values, the purpose in design should be to reach these limits in as many parts of the structure as possible and to adopt a layout such that maximum structural efficiency is attained for a minimum use of steel. Careful consideration should therefore be given to the semi-rigid basis and fully rigid basis of design.

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.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 78, 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.

1 Scope

This British Standard relates primarily to the use in building of hot rolled steel sections and plates, and normalized tubular shapes.

The use in building of cold formed sections in light gauge plate, sheet and strip steel 6 mm thick and under is dealt with in Addendum No. 1 to BS 449-2:1969.

The provisions of this standard are not deemed to apply to transmission towers and farm buildings; nor to structures which are designed on an experimental basis, except in so far as provided by Clause 9 c) and Appendix A.

Chapter 1. Definitions

2 Definitions

For the purposes of this British Standard the following definitions apply:

beam or girder

any structural member which supports load primarily by its internal resistance to bending

dead load

the weight of all permanent construction

effective lateral restraint

restraint which will produce sufficient resistance in a plane perpendicular to the plane of bending to restrain a loaded beam from buckling to either side at the point of application of restraint

engineer

the person responsible for the design and satisfactory completion of the structure, as covered by this specification

filler joists

rolled steel I-beams or other suitable flanged sections used in combination with structural concrete and forming the skeleton of a floor or roof slab

foundation

that part of the building the function of which is to distribute loading direct to the ground. It may include any retaining or other wall, based upon the ground, of sufficient strength and stability to carry its own weight together with the loads and forces imposed upon it

high strength friction grip bolts

high strength friction grip bolts are bolts of high tensile steel, used in conjunction with high strength nuts and hardened steel washers, which are tightened to a pre-determined shank tension in order that the clamping action thus afforded will transfer loads in the connected members by friction between the parts in contact and not by shear or bearing in the bolts (See footnote to Clause 48.)

imposed load

in respect of a building: all loads other than the dead load

load factor

the numerical value by which the load which would cause failure of the structure is divided to give the permissible working load on the structure

panel wall

a wall built between pillars, stanchions or other members and supported by the steel framework or foundations

partition

an internal vertical structure which is employed solely for the purpose of subdividing any storey of a building into sections, and which supports no load other than its own weight

strut

a steel pillar, stanchion, column or other compression member

welding terms

except as otherwise defined in this British Standard, the terms used in the welding clauses have the meanings given in BS 499, "Welding terms and symbols"

wheel loads

the static weights imposed by the wheels when the appliance of which the wheels form part is fully loaded

yield stress

the yield stress in tension

Chapter 2. Materials

3 Structural steel and electrodes

a) Structural steel¹⁾

i) All structural steel used in building coming within the purview of this British Standard shall, before fabrication, comply with grade 43, 50 or 55 of BS 4360²⁾ and with such additional requirements as may be given in Subclauses ii) to vi) below.

ii) As a precaution against brittle fracture, steel used for elements which are subject to tensile stresses in service due to applied axial load or moment, shall comply with the following requirements:

1) Sections, plates, wide flats, flats and bars in elements which are subject to tensile stresses exceeding 60 N/mm^2 at welded locations, may be used up to the following thickness:

Grade	Section, plates flats and bars	Wide flats
43A	25 mm	25 mm
43B	30 mm	30 mm
43C	60 mm	50 mm
43D	100 mm	50 mm
50A	20 mm	20 mm
50B	25 mm	25 mm
50C	45 mm	45 mm
50D	100 mm	50 mm

For grades 43B and 50B, option B.39 of BS 4360²⁾ shall be invoked when the steel is ordered.

2) Sections, plates, wide flats and bars in other tension elements may be used up to double the above thicknesses subject to a maximum thickness of 100 mm generally or 50 mm for wide flats.

3) Hot rolled hollow sections of grades 43C and 50C may be used up to a maximum thickness of 16 mm for rectangular hollow sections or 40 mm for circular hollow sections.

4) Steel of grade 55C may be used up to the following thicknesses:

Sections, flats and bars	19 mm
Plates, wide flats and circular hollow sections	25 mm
Rectangular hollow sections	16 mm

NOTE For members containing unreamed punched holes, see also Clause 59 d).

iii) The requirements in Subclause ii) above apply to the general use of structural steelwork in the United Kingdom, but further consideration is to be given to this aspect by the designer in the following circumstances:

- 1) Critical conditions where a single failure would result in the collapse of a major part of the structure.
- 2) Positions where complicated details are involved which may lead to high restraint and difficulties in inspection or testing or both.
- 3) Dynamic or shock loading producing tension.
- 4) Structures in which important elements of the steelwork are used in circumstances where the temperature may be below -7°C .

iv) Under any of the conditions in Subclause iii) above, one or more of the following safeguards additional to ii) above may be advisable:

- 1) Impact test requirements to be imposed on materials thinner than those specified in Subclause ii) above.
- 2) The impact test requirement to be increased.
- 3) Stress relieving to be carried out on the material.

v) In addition to the requirements of Subclause ii) above, where ambient temperatures below -7°C occur in service, the steel used shall have a minimum Charpy V-notch impact test value at the lowest ambient temperature of not less than the following:

grade 43	$0.4t$ Joules
grade 50	$0.5t$ Joules
grade 55	$0.6t$ Joules

where t is the thickness in mm.

For steelwork used in external conditions in the UK the ambient temperature may be taken as -15°C .

¹⁾ A new specification for rivet steel, BS, "Steel rivet bars for the manufacture of structural and general engineering rivets" is in course of preparation.

²⁾ BS 4360, "Weldable structural steels".

vi) For any conditions dealt with in Subclauses ii) to v) above, the impact test pieces shall be cut from the sections as specified in BS 4360³⁾.

b) **High tensile steel rivets.** Where high tensile steel is used for rivets, steps shall be taken to ensure that the rivets are so manufactured that they can be driven and the heads formed satisfactorily; and that the physical properties of the steel are not impaired.

c) **Electrodes.** Mild steel electrodes and high tensile steel electrodes shall comply with the requirements of BS 639, "Covered electrodes for the manual metal-arc welding of mild steel and medium-tensile steel".

d) **Steel for bolts and nuts**

Bolts and nuts shall comply with one of the following specifications:

- | | |
|----------|---|
| BS 3692. | ISO metric precision hexagon bolts, screws and nuts. |
| BS 4190. | ISO metric black hexagon bolts, screws and nuts. |
| BS 4933. | ISO metric black cup and countersunk head bolts and screws with hexagon nuts. |

e) **Washers.** Plain washers shall be made of steel. Taper or other specially shaped washers shall be made of steel or malleable cast iron. (See BS 4320, "Metal washers for general engineering purposes. Metric series.")

4 Other materials

Other materials used in the structure in association with steelwork shall conform to any bye-laws or regulations to which the building has to conform.

Where an appropriate British Standard for a particular material exists the material shall also comply with that British Standard, except where it may conflict with, or differ from, the requirements of any relevant bye-law or regulation.

5 Standard dimensions

The dimensions of all structural rolled shapes, and the form, weight, tolerance, etc., of all rolled shapes and other members used in any structure shall, whenever possible, conform to the latest appropriate standards of the British Standards Institution.

The dimensions or form and the weight, tolerances, etc., of all rivets, bolts, nuts, studs, etc., shall conform to the requirements of the latest appropriate standards of the British Standards Institution.

³⁾ BS 4360, "Weldable structural steels".

Chapter 3. Loads

6 Dead loads and imposed loads

Reference should be made to CP 3:Chapter V, "Loading":

- 1) for recommendations on the determination of the dead load; and
- 2) for recommended values of imposed loads on floors, corridors, balconies, stairs and landings, parapets and balustrades; of snow and other loads; and of wind loads on buildings and unclad structures (including sheeted towers and chimneys).

7 Dynamic loads

Where loads arising from machinery, runways, cranes and other plant producing dynamic effects are supported by or communicated to the framework, allowance shall be made for these dynamic effects, including impact, by increasing the deadweight values by an adequate percentage.

In order to ensure due economy in design the Engineer shall ascertain as accurately as possible the appropriate dynamic increase for all members affected.

For crane gantry girders the following allowances shall be deemed to cover all forces set up by vibration, shock from slipping of slings, kinetic action of acceleration and retardation, impact of wheel loads and skew loads due to travelling:

1) For loads acting vertically, the maximum static wheel loads shall be increased by the following percentages:

for electric overhead cranes	25 per cent
for hand-operated cranes	10 per cent

Values for cranes for loading class Q3 and Q4 as defined in BS 2573-1 shall be established in consultation with the crane manufacturer.

2) The horizontal force acting transverse to the rails shall be taken as a percentage of the combined weight of the crab and the load lifted as follows:

for electric overhead cranes	10 per cent
for hand-operated cranes	5 per cent

This force shall be taken into account when considering the lateral rigidity of the rails and their fastenings. Provided that both gantry girders supporting the crane are similar, this horizontal force may be assumed to be shared equally between the two supporting girders.

3) Horizontal forces acting along the rails shall be taken as a percentage of the static wheel loads which can occur on the rails, as follows:

for overhead cranes, either	
electric or hand-operated	5 per cent

4) For gantry girders intended to carry cranes of class Q3 and Q4 as defined in BS 2573-1, two equal and opposite horizontal forces acting transverse to the rail, one at each end of the wheelbase, of the magnitude specified in Clause 3.1.5.2 of BS 2573-1. The forces specified in 2), 3) or 4) above shall be considered as acting at the rail level and being appropriately transmitted to the supporting systems.

Gantry girders and their supporting structures shall be designed on the assumption that the horizontal forces 2), 3) and 4) are alternatives which do not act at the same time but that each of them may act at the same time as the vertical load.

An increase of 10 per cent on the allowable stresses specified in this standard shall be allowable for the combination of loadings 1) and 2), 3) or 4) above in respect of the design of the gantry girders and supporting structures. This increase is not however in addition to that permitted in Clause 13.

In special cases, e.g. charging machines, and where more than one crane is in use on the gantry and where high speeds are attained, the above allowances should be reconsidered.

For cranes on outdoor gantries the wind loads on the gantry and supporting structure shall be obtained from:

- a) BS 2573-1, for cranes in the working condition;
- b) CP 3:Chapter V-2, for cranes which are not working.

Where a structure or member is subject to loads from two or more cranes, the crane loads shall be taken as the maximum vertical and horizontal loads acting simultaneously. Loading on steel over-head runway beams shall be as specified in BS 2853.

NOTE For factors applicable to the allowable working stresses, and detailed design under fatigue conditions, see BS 2573-1.

8 Temperature range

Where, in the design and erection of a building, it is necessary to take account of a change of temperature, it shall be assumed that the average temperature of the metal in the structure in Great Britain and Northern Ireland does not vary over a range greater than from -7°C to $+50^{\circ}\text{C}$. The design range, however, depends on the location, type and purpose of the building. Special consideration will be necessary for structures in special conditions and in localities abroad subject to different temperature ranges.

Chapter 4. Design and details of construction

A. General

9 Steel framework

a) Any part of the structure shall be capable of sustaining the most adverse combination of static and dynamic forces which may reasonably be expected from dead loads and all imposed loads, including snow and wind loads, referred to in Chapter 3, without the allowable stresses specified in Chapter 4 being exceeded. The design and details of parts and components shall be compatible so that the required overall stability is achieved.

NOTE This is best ensured by making one person responsible for this compatibility when some or all of the design and details are not made by the same designer.

b) The following methods may be employed in the design of the steel framework:

- 1) *Simple design.* This method applies to structures in which the end connections between members are such that they will not develop restraint moments adversely affecting the members and the structure as a whole and in which the structure may, for the purposes of design, be assumed to be pin-jointed.

This method of design involves the following assumptions:

Beams are simply supported.

All connections of beams, girders or trusses are proportioned to resist the reaction shear forces applied at the appropriate eccentricity.

Members in compression are subjected to loads applied at the appropriate eccentricities (see Clause 34 for stanchions), with the effective lengths given in Clauses 30 and 31.

Members in tension are subjected to longitudinal loads applied over the net area of the section, as specified in Clause 42.

2) *Semi-rigid design*. This method, as compared with the simple design method, permits a reduction in the maximum bending moment in beams suitably connected to their supports, so as to provide a degree of direction fixity and, in the case of triangulated frames, it permits account being taken of the rigidity of the connections and the moment of interaction of members. In cases where this method of design is employed, calculations based on general or particular experimental evidence shall be made to show that the stresses in any part of the structure are not in excess of those laid down in this British Standard.

An allowance may be made for the inter-restraint of the connection between a beam and a column by a moment not exceeding 10 per cent of the free-moment applied to the beam, assuming this to be simply supported, provided:

A) The beams and columns are designed by the general rules for members of a simply supported frame.

B) The beams are designed for the maximum net moment with due allowance for any difference in the restraint moment at each end.

C) Each column is designed to resist the algebraic sum of the restraint moments from the beams at the same level on each side of the column, in addition to moments due to eccentricity of connection (see Clause 34).

D) The assumed end restraint moment need not however be taken as 10 per cent of the free-moment for all beams, provided that the same value of the restraint moment is used in the design of the column and the beam at each connection.

E) The column is fully encased in concrete in accordance with Clause 30 b) and the beam to column connection includes a top cleat.

3) *Fully rigid design*. This method, as compared with the method for simple and semi-rigid design, will give the greatest rigidity and economy in weight of steel used when applied in appropriate cases. For this purpose the design shall be carried out in accordance with accurate methods of elastic analysis and to the limiting stresses permitted in this British Standard. Alternatively, it shall be based on the principles of plastic design so as to provide a load factor of not less than 1.7 when considering only gravity loading and 1.36 when considering the combined effects of wind loads and gravity loading, and with deflections under working loads not in excess of the limits implied in this British Standard.

Due consideration shall also be given to the possibility of member instability and frame instability, both for elastic analysis of rigid-jointed frames and also when plastic design is used. The notional horizontal forces specified in Subclause 10 c) shall be included in the frame stability check.

c) **Experimental basis**. Where, by reason of the unconventional nature of the construction, calculation is not practicable, or where the methods of design given in b) above are inapplicable or inappropriate, loading tests shall be made, in accordance with the procedure set out in Appendix A, to ensure that the construction has:

1) adequate strength to sustain a total load equal to twice the sum of the dead load and the imposed load, and

2) adequate stiffness to resist, without excessive deflection, a total load equal to the sum of the dead load and 1½ times the imposed load and, in the case of a beam, to satisfy Clause 15.

d) **Curved members and bends**. The design of curved or bent members shall be given special consideration. Allowance shall be made for any thinning of the bent part which may be caused by bending the member.

10 Resistance to horizontal forces

a) General.

i) When considering the effect of wind pressure on buildings, due allowance shall be made for the resistance and stiffening effects of floors, roofs and walls.

ii) When the floors, roof and walls are incapable of transmitting the horizontal forces to the foundation, the necessary steel framework shall be provided to transmit the forces to the foundations. This framework may be in the form of triangulated bracing to members, portal construction or cantilevers which shall comprise all members necessary effectively to transmit the forces to the foundations.

Resistance to the wind forces on the sides and roof of a building shall be provided by horizontal or inclined bracing or beam systems designed to transmit the wind loads direct to the foundations or to intermediate transverse frames or to end frames, and those frames shall be designed to transmit the loads to the foundations.

Resistance to the wind forces on the ends and roof of a building shall likewise be provided by horizontal or inclined bracing or beam systems designed to transmit the wind loads to the side framing, and the side framing shall be braced to transmit these loads to the foundations, or, alternatively, the wind forces on the ends may be taken direct to the foundations by vertical cantilevers.

In buildings where high-speed travelling cranes are supported by the structure or where a building or structure may be otherwise subject to vibration or sway, triangulated bracing or especially rigid portal systems shall be provided to reduce the vibration or sway to a suitable minimum.

b) Stability. The stability of the structure as a whole, or of any part of it shall be investigated, and weight or anchorage shall be provided so that the least restoring moment, including anchorage, shall be not less than the sum of 1.4 times the maximum overturning moment due to dead loads and 1.6 times the maximum overturning moment due to imposed loads.

When considering wind loads, the restoring moment shall not be less than 1.4 times the overturning moment due to dead loads and wind loads, nor less than 1.2 times the overturning moment due to the combined effects of dead, imposed and wind loads.

To ensure stability at all times account shall be taken of probable variations in dead load during construction, repair or other temporary measures.

In complying with the requirements of this clause it is necessary to ascertain that the resulting pressures and shear forces to be communicated by the foundations to the supporting soil would not produce failure.

All parts of the structure which have been designed for their dead, imposed and wind loads to the allowable stresses in this British Standard shall be deemed to be adequately covered for this margin of stability provided that no stress reversal takes place in the part when the loads contributing to the overturning moment are increased by the factors specified above whilst the loads contributing to the restoring moment remain unfactored.

Where such stress reversal occurs, the resulting stresses may exceed the allowable stresses in the relevant clauses of Chapter 4 of this standard by 40 per cent. This increase is not, however, in addition to that permitted in Clause 13 or in Clause 40.

c) Sway-stability. All structures including portions between expansion joints shall be adequately strong and stiff to resist sway. To ensure adequate strength, in addition to designing for applied horizontal loads, a separate check shall be carried out for notional horizontal forces which can arise due to practical imperfections such as lack of verticality.

These notional horizontal forces shall be applied at each roof and floor level or their equivalent and shall be taken as equal to 0.5 per cent of the sum of the dead and imposed gravity loads applied at that level, but not less than 1.0 per cent of the dead load.

The notional horizontal forces shall be taken as acting simultaneously with the vertical loads. They shall be assumed to act in any one horizontal direction at a time.

Notional horizontal forces shall not be applied when:

- considering stability against overturning.
- applying wind loads or other horizontal loads.
- considering temperature effects.
- determining horizontal loads on foundations.

Whatever system is used to resist horizontal forces [see Subclause 10 a)], reversal of loading shall be accommodated. Where floors, walls or roofs are used to provide sway stability, they shall have adequate strength and be so secured to the structural framework as to transmit all horizontal forces to points of sway resistance. Where such sway stability is to be provided by construction other than the steel framework, the need for such construction and the forces acting upon it shall be clearly stated.

11 Foundations

The foundations of a building or other structure shall be so designed as to limit the pressures on the sub-soil to safe bearing values and to ensure such rigidity and restraints as have been allowed for in the design of the super-structure, including resistance to all horizontal forces. Due regard shall be paid to the effects of temperature and seasonal changes generally.

The weight of foundations shall be such as to comply with Subclause 10 b).

12 Minimum thickness of metal

The following provisions shall apply, except in the case of members on which special protection against corrosion is provided:

- 1) **General.** Steel used for external construction exposed to the weather or other corrosive influences shall be not less than 8 mm thick; and in construction not so exposed, not less than 6 mm thick. These provisions do not apply to the webs of British Standard rolled steel joints and channels, or to packings.
- 2) **Sealed tubes or sealed box sections.** Sealed tubes or sealed box sections used for external construction exposed to the weather shall be not thinner than 4 mm and for construction not so exposed shall be not thinner than 3 mm.

13 Stresses due to wind forces

Unless otherwise stated, the allowable stresses specified in the relevant clauses of Chapter 4 of this standard may be exceeded by 25 per cent in cases where an increase in stress is solely due to wind forces, provided that the steel section shall be not less than that needed if the wind stresses were neglected.

This provision does not apply to grillage beams (see Clause 40).

In the case of any combination of stresses arising from bending and axial loading, including the effects of wind, the values of p_c and p_{bc} in Clause 14 a) and p_t and p_{bt} in Subclause 14 b) shall be increased by 25 per cent in satisfying the relationship to unity, provided that Subclauses 14 a) and b) shall also apply in respect of any combination of stresses arising from bending and axial loading not due to wind.

14 Combined stresses

a) **Bending and axial compression.** Members subject to both axial compression and bending stresses shall be so proportioned that, at any point:

$$\frac{f_c}{p_c} + \frac{f_{bcx}}{p_{bcx}} + \frac{f_{bcy}}{p_{bcy}} \leq 1$$

where

- f_c = the calculated average axial compressive stress.
- p_c = the allowable compressive stress in axially loaded struts (see Table 17).
- f_{bcx} and f_{bcy} = the compressive stresses due to bending about the respective rectangular axis.

p_{bcx} and p_{bcy} = the appropriate allowable compressive stresses for members subject to bending (see Clause 19).

In cased struts for which allowance is made for the load carried by the concrete in accordance with Subclause 30 b), the ratio f_c/p_c in the above expression shall be replaced by the ratio of the calculated axial load on the strut to the allowable axial load determined from Subclause 30 b)

b) **Bending and axial tension.** Members subject to both axial tension and bending stress shall be so proportioned that, at any point:

$$\frac{f_t}{p_t} + \frac{f_{bt}}{p_{bt}} \leq 1$$

and

$$\frac{f_{bcx}}{p_{bcx}} + \frac{f_{bcy}}{p_{bcy}} \leq 1$$

where

f_t = the calculated axial tensile stress.

p_t = the permissible axial tensile stress (see Clause 41).

f_{bt} = the resultant tensile stress due to bending about both principal axes.

p_{bt} = the appropriate allowable tensile stress in bending (see Clause 19).

p_{bcx} = the appropriate allowable compressive stress for members subject to bending about the major axis (see Clause 19).

c) **Bending and shear.** The equivalent stress f_e due to bending and shear shall not exceed the values of p_e given in Table 1.

The equivalent stress f_e is obtained from the following formula:

$$f_e = \sqrt{(f_{bt}^2 + 3f_q^2)} \quad \text{or} \quad \sqrt{(f_{bc}^2 + 3f_q^2)}$$

in which f_{bc} or f_{bt} , and f_q are the numerical values of the co-existent bending and shear stresses.

In addition the following relationship shall be satisfied:

$$\left[\frac{f_{bc}}{p_o} \right]^2 + \left[\frac{f_q'}{p_q'} \right]^2 \leq 1.25$$

where

f_q' = the average shear stress in the web.

p_q' = the allowable shear stress specified in Subclause 23 b).

p_o = the allowable bending stress specified in Clause 20 item 2 b) iii).

d) **Combined bearing, bending and shear stresses.** Where a bearing stress is combined with tensile bending and shear stresses under the most unfavourable conditions of loading, the equivalent stress f_e , obtained from the following formulae, shall not exceed the values of p_e given in Table 1.

$$f_e = \sqrt{(f_{bt}^2 + f_b^2 + f_{bt}.f_b + 3f_q'^2)} \\ \text{or } f_e = \sqrt{(f_{bc}^2 + f_b^2 - f_{bc}.f_b + 3f_q'^2)}$$

in which f_{bt} , f_{bc} , f_q' and f_b are the numerical values of the co-existent bending, shear and bearing stresses.

In addition the following relationship shall be satisfied:

$$\left[\frac{f_{bc}}{p_o} \right]^2 + \left[\frac{f_q'}{p_q'} \right]^2 + \frac{f_{cw}}{p_{cw}} \leq 1.25$$

Where f_q' , p_q' and p_o are as defined in Subclause 14 c) and f_{cw} and p_{cw} are as defined in Subclause 28 a).

Table 1 — Allowable Equivalent Stress p_e

Form	Grade	Thickness	P_e
Sections, bars, plates, wide flats and hot rolled hollow sections	43	≤ 40	250
		40 but ≤ 100	230
	50	≤ 63 63 but ≤ 100	320 295
	55	≤ 25	390
NOTE The increases permitted by clauses 7 and 13 do not apply to these values.			

15 Deflection of beams

The maximum deflection of a beam shall be such as will not impair the strength and efficiency of the structure, lead to damage of the finishings or be unsightly.

Measures may be necessary to nullify the effects of the deflection due to dead load by cambering or by adjustment in the casing.

The maximum deflection due to loads other than the weight of the structural floors or roof, steelwork and casing, if any, shall not exceed 1/360 of the span.

16 Overhang of walls

Where a wall, or leaf of a cavity wall, is placed eccentrically upon the flange of a supporting steel beam, the beam and its connections shall be designed for torsion, unless the beam is encased in solid concrete and reinforced in combination with an adjoining slab in such a way as to prevent the beam deforming torsionally.

17 Sectional areas

a) **General.** The gross sectional area shall be taken as the area of the cross section as calculated from the specified size.

The net sectional area shall be taken as the gross sectional area less deductions for rivet holes, bolt holes and open holes, or other deductions specified in this standard.

In making deductions for rivet and bolt holes the diameter of the hole shall be assumed to be 2 mm in excess of the nominal diameter of the rivet or bolt unless otherwise specified. For countersunk rivets or bolts the appropriate addition shall be made to the diameter of the hole.

Except as required by the following paragraph, the areas to be deducted shall be the sum of the sectional areas of the maximum number of holes in any cross section at right angles to the direction of stress in the member.

For 1) all axially loaded tension members;

2) plate girders of grade 43 steel and with d_1/t greater than 85;

3) plate girders of grade 50 steel and with d_1/t greater than 75; and

4) plate girders of grade 55 steel and with d_1/t greater than 65

(where t = the thickness of the web, and d_1 is the depth defined in Subclause 23 b as d (i) for vertically stiffened webs without horizontal stiffeners)

the area to be deducted when the holes are staggered shall be that given above or, if greater, the sum of the sectional areas of all holes in any zig-zag line extending progressively across the member or

part of the member, less $\frac{s^2 t_1}{4G}$ for each gauge space in the chain of holes,

where s = the staggered pitch, i.e. the distance, measured *parallel* to the direction of stress in the member, centre-to-centre of holes in consecutive lines.

t_1 = the thickness of the holed material.

G = the gauge, i.e. the distance measured *at right angles* to the direction of stress in the member, centre-to-centre of holes in consecutive lines.

For sections such as angles with holes in both legs the gauge shall be measured along the centre of the thickness of the angle.

NOTE In a built-up member where the chains of holes considered in individual parts do not correspond with the critical chain of holes for the member as a whole, the value of any rivets or bolts joining the parts between such chains of holes shall be taken into account in determining the strength of the member.

b) Rivets. The nominal diameter of a rivet shall be the diameter cold before driving.

The gross area of a rivet shall be the cross-sectional area of the rivet hole.

c) Bolts and screwed tension rods. The net sectional area of a bolt or screwed tension rod with ISO metric threads shall be taken as the tensile stress area of the threaded part or the cross-sectional area of the unthreaded part, whichever is the lesser.

NOTE The tensile stress areas of ISO metric bolts are given in BS 3692, BS 4190 and BS 4933

18 Separators and diaphragms

Where two or more rolled steel joists or channels are used side by side to form a girder, they shall be connected together at intervals of not more than 1.5 m except in the case of grillage beams encased in concrete, where it is only necessary to make suitable provision for maintaining correct spacing. Through bolts and separators may be used provided that in beams having a depth of 300 mm or more not less than 2 bolts in the depth are used with each separator. When loads are required to be carried from one beam to the other or are required to be distributed between the beams, diaphragms and their fastenings designed with sufficient stiffness to distribute the load shall be used.

When loads are required to be carried from one tube to another, or are required to be distributed between tubes, diaphragms (which may be tubular) and their fastenings, designed with sufficient stiffness to distribute the load between the tubes, shall be used.

B. Design of members subject to bending

19 Bending stresses (beams other than plate girders)

a) Rolled I-Beams. Universal beams and columns and rolled channels. The bending stress in the extreme fibres, calculated on the effective section, shall not exceed:

1) for parts in tension, the appropriate value of p_{bt} in Table 2, and

2) for parts in compression,

A) for bending about the major axis (except as specified in Case B) the lesser of the values of p_{bc} given in Table 2 and Table 3a, Table 3b or Table 3c, as appropriate;

B) for bending about the major axis in beams with the applied loading substantially concentrated within the middle fifth of the unrestrained length or in columns with moments arising from the eccentricities specified in Clause 34, the lesser of the values of p_{bc} given in Table 2 and Table 4a, Table 4b or Table 4c as appropriate;

C) for bending about the minor axis, the appropriate value of p_{bc} in Table 2.

In Tables 3 and 4:

l = effective length of compression flange (see Clause 26)

r_y = radius of gyration about the minor axis

D = overall depth of beam

T = mean thickness of flange

= area of horizontal portion of flange, divided by its width.

For rolled sections, the mean thickness is that given in the appropriate British Standards or other reference book.

Tables 3 and 4 apply to ordinary building structures with simple end connections such as end plates or cleats. Where the end connections provide less restraint, the effective length l obtained from Clause 26 shall be increased by 10 per cent.

b) Compound beams. The bending stress in compound beams having equal flanges of uniform cross section throughout shall not exceed the values of p_{bc} and p_{bt} specified in Subclause 19 a).

Where flanges are unequal or vary in sections between points of effective lateral restraint, the procedures specified in Clause 20 shall be applied.

c) **Angles and tees.** The bending stress in the leg when loaded with the flange or table in compression shall not exceed the appropriate value of p_{bt} in Table 2. When loaded with the leg in compression, the permissible compressive stress shall be calculated from Clause 20, with $K_2 = -1.0$ and T = thickness of leg.

d) **Tubes and rectangular hollow sections.** The bending stresses in tubes and rectangular hollow sections, where the ratio of depth to breadth is not greater than 4, shall not exceed the appropriate values of p_{bt} and p_{bc} in Table 2.

e) **Castellated beams.** The bending stresses in tension or compression calculated from the net section properties with due allowance for the secondary vierendeel effects of shear at the openings and the local effects of point loads, if any, at any point in the length of the beam, shall not exceed the appropriate value of p_{bc} or p_{bt} in Table 2.

In addition the compressive stress in the extreme fibres, calculated neglecting secondary effects, shall not exceed the appropriate value of p_{bc} obtained as specified for plate girders in Clause 20, except that the 20 per cent increase in the value of C_s shall not be applied to castellated beams.

Table 2 — Allowable stress p_{bc} or p_{bt} in bending
(See also Clauses 19 and 20 and Tables 3 and 4)

Form	Grade	Thickness of material	p_{bc} or p_{bt}
Sections, bars, plates, wide flats and hot rolled hollow sections. Compound beams composed of rolled sections plated, with thickness of plate. Double channel sections forming a symmetrical I-section which acts as an integral unit.	43	≤ 40 > 40 but ≤ 100	180 165
	50	≤ 63 > 63 but ≤ 100	230 215
	55	≤ 25	280
Plate girders with single or multiple webs	43	≤ 40 > 40 but ≤ 100	170 155
	50	≤ 63 > 63 but ≤ 100	215 200
	55	≤ 25	265
Slab bases	All steels		185

Table 3a — Allowable stress p_{bc} in bending (N/mm²) for case A of Clause 19 a) 2) for grade 43 steel

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	180	180	180	180	180	180	180	180	180	180
45	180	180	180	180	180	180	180	180	180	180
50	180	180	180	180	180	180	180	180	180	180
55	180	180	180	178	176	175	174	174	173	173
60	180	180	176	172	170	169	168	167	167	166
65	180	180	172	167	164	163	162	161	160	160
70	180	177	167	162	159	157	156	155	154	154
75	180	174	163	157	154	151	150	149	148	147
80	180	171	159	153	148	146	144	143	142	141
85	180	168	156	148	143	140	138	137	136	135
90	180	165	152	144	139	135	133	131	130	129
95	180	162	148	140	134	130	127	125	124	123
100	180	160	145	136	129	125	122	119	118	117
105	180	157	142	132	125	120	116	114	112	111
110	180	155	139	128	120	115	111	108	106	105
115	178	152	136	124	116	110	106	103	101	99
120	177	150	133	120	112	106	101	98	96	95
130	174	146	127	113	104	97	94	91	89	88
140	171	142	121	107	97	92	88	85	83	81
150	168	138	116	100	92	87	82	79	77	75
160	166	134	111	96	88	82	77	74	72	70
170	163	130	106	92	84	77	73	69	67	65
180	161	126	102	89	80	73	69	65	63	60
190	158	123	97	85	76	70	65	61	59	56
200	156	119	95	82	73	66	62	58	55	53
210	154	116	92	79	70	63	58	55	52	50
220	151	113	90	77	67	61	56	52	49	47
230	149	110	87	74	65	58	53	49	47	44
240	147	107	85	72	62	56	51	47	44	42
250	145	104	83	69	60	53	48	45	42	40
260	143	101	80	67	58	51	46	43	40	38
270	141	98	78	65	56	49	45	41	38	36
280	139	96	76	63	54	48	43	39	37	35
290	137	94	75	61	52	46	41	38	35	33
300	135	93	73	60	51	44	40	36	34	32

**Table 3b — Allowable stress p_{bc} in bending (N/mm^2) for case A of Clause 19 a) 2)
for grade 50 steel**

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	230	230	230	230	230	230	230	230	230	230
45	230	230	230	230	230	230	230	230	230	230
50	230	230	230	230	230	230	229	228	228	228
55	230	230	230	225	223	221	220	219	219	219
60	230	230	223	218	214	213	211	210	210	209
65	230	229	217	210	207	204	203	202	201	200
70	230	224	211	203	199	196	194	193	192	192
75	230	220	205	197	192	188	186	185	183	183
80	230	215	200	190	184	181	178	176	175	174
85	230	211	194	184	177	173	170	168	166	165
90	230	207	189	178	170	166	162	160	158	157
95	230	204	184	172	164	158	154	152	150	148
100	230	200	180	166	157	151	147	144	142	140
105	230	197	175	161	151	144	140	136	133	132
110	228	193	171	155	145	138	132	128	126	123
115	226	190	166	150	139	131	125	121	118	115
120	224	187	162	145	133	124	118	113	111	109
130	220	181	154	135	122	112	108	104	101	99
140	216	175	146	126	112	105	99	96	93	91
150	212	169	139	117	105	98	92	88	85	83
160	208	164	132	110	99	91	86	82	79	76
170	205	158	126	105	94	86	80	76	73	70
180	201	153	119	100	89	81	75	71	67	65
190	198	149	113	96	84	76	70	66	63	60
200	195	144	109	92	80	72	66	62	59	56
210	192	139	105	88	76	68	63	58	55	53
220	189	135	102	85	73	65	59	55	52	49
230	185	130	99	81	70	62	56	52	49	47
240	183	126	95	78	67	59	54	50	46	44
250	180	122	92	75	64	57	51	47	44	42
260	177	118	90	73	62	54	49	45	42	40
270	174	114	87	70	60	52	47	43	40	38
280	171	111	84	68	58	50	45	41	38	36
290	169	109	82	66	56	48	43	40	37	34
300	166	106	80	64	54	47	42	38	35	33

Table 3c — Allowable stress p_{bc} in bending (N/mm²) for case A of Clause 19 a) 2) for grade 55 steel

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	280	280	280	280	280	280	280	280	280	280
45	280	280	280	280	280	280	280	280	280	280
50	280	280	280	280	278	276	275	275	274	274
55	280	280	276	270	267	265	264	263	262	262
60	280	280	268	261	257	254	252	251	251	250
65	280	275	260	251	246	243	241	240	239	238
70	280	269	252	242	236	233	230	229	227	227
75	280	263	244	233	227	222	219	217	216	215
80	280	258	237	225	217	212	209	206	205	204
85	280	252	230	217	208	202	198	196	194	192
90	280	247	224	209	199	193	188	185	183	181
95	280	242	217	201	190	183	178	175	172	170
100	280	238	211	194	182	174	168	164	161	159
105	277	233	205	186	174	165	159	154	151	148
110	275	229	199	179	166	156	149	144	140	137
115	272	224	194	172	158	147	140	134	130	127
120	269	220	188	166	150	139	131	125	121	119
130	264	212	178	153	135	123	117	113	110	107
140	258	205	168	141	122	113	107	103	99	97
150	253	197	158	130	114	105	99	94	90	88
160	249	190	149	121	107	98	91	86	83	80
170	244	183	140	114	100	91	84	80	76	73
180	239	177	132	108	95	85	79	74	70	68
190	235	170	124	103	89	80	74	69	65	63
200	231	164	119	98	85	76	69	64	61	58
210	227	158	114	94	80	71	65	61	57	54
220	223	152	110	90	77	68	62	57	54	51
230	219	147	106	86	73	65	58	54	51	48
240	215	141	102	83	70	62	56	51	48	45
250	211	136	99	79	67	59	53	49	45	43
260	207	130	96	76	64	56	51	46	43	41
270	204	125	92	74	62	54	48	44	41	39
280	200	121	90	71	60	52	46	42	39	37
290	197	118	87	69	58	50	45	41	38	35
300	193	115	84	67	56	48	43	39	36	34

**Table 4a — Allowable stress p_{bc} in bending (N/mm²) for case B of Clause 19 a) 2)
for grade 43 steel**

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	180	180	180	180	180	180	180	180	180	180
45	180	180	180	180	180	180	180	180	180	180
50	180	180	180	180	180	180	180	180	180	180
55	180	180	180	180	180	180	180	180	180	180
60	180	180	180	180	180	180	179	178	178	178
65	180	180	180	178	176	175	174	173	172	172
70	180	180	179	174	171	170	168	168	167	167
75	180	180	175	170	167	165	163	162	162	161
80	180	180	172	166	162	160	158	157	156	156
85	180	179	168	162	158	155	153	152	151	150
90	180	176	165	158	154	151	149	147	146	145
95	180	174	162	155	150	146	144	142	141	140
100	180	172	159	151	146	142	139	137	136	135
105	180	170	156	148	142	137	135	132	131	130
110	180	168	154	144	138	133	130	128	126	125
115	180	166	151	141	134	129	126	123	121	120
120	180	164	148	138	131	125	121	119	116	115
130	180	160	144	132	124	118	113	110	107	105
140	180	156	139	126	117	110	105	101	98	96
150	179	153	134	121	111	103	97	94	92	91
160	177	149	130	116	105	97	93	89	87	85
170	175	146	126	111	99	93	88	85	82	80
180	173	143	122	106	95	89	84	80	77	75
190	171	140	118	101	92	85	80	76	73	71
200	169	137	114	97	88	82	76	72	69	67
210	167	134	111	94	85	78	73	69	66	63
220	165	132	107	92	82	75	70	66	62	60
230	163	129	104	89	80	72	67	63	59	57
240	161	126	101	87	77	70	64	60	57	54
250	159	124	97	85	75	67	62	57	54	51
260	158	121	95	82	72	65	59	55	52	49
270	156	119	94	80	70	63	57	53	50	47
280	154	116	92	78	68	61	55	51	48	45
290	152	114	90	76	66	59	53	49	46	43
300	151	112	88	74	64	57	51	47	44	41

Table 4b — Allowable stress p_{bc} in bending (N/mm²) for case B of Clause 19 a) 2) for grade 50 steel

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	230	230	230	230	230	230	230	230	230	230
45	230	230	230	230	230	230	230	230	230	230
50	230	230	230	230	230	230	230	230	230	230
55	230	230	230	230	230	230	230	230	230	230
60	230	230	230	230	229	228	227	226	225	225
65	230	230	230	226	223	221	219	218	218	217
70	230	230	226	220	216	214	212	211	210	210
75	230	230	221	214	210	207	205	204	203	202
80	230	230	217	209	204	200	198	196	195	195
85	230	227	212	203	197	194	191	189	188	187
90	230	223	208	198	192	187	184	182	181	180
95	230	220	203	193	186	181	178	175	174	172
100	230	217	199	188	180	175	171	169	167	165
105	230	214	195	183	175	169	165	162	160	158
110	230	211	192	179	170	163	159	155	153	151
115	230	208	188	174	164	158	153	149	146	144
120	230	206	184	170	159	152	147	143	139	137
130	230	200	177	161	150	141	135	130	126	124
140	230	195	171	153	140	131	124	118	114	111
150	227	190	165	146	132	121	113	109	106	103
160	224	186	159	139	123	112	106	102	98	96
170	221	181	153	132	115	106	100	95	92	89
180	218	177	147	125	109	101	94	90	86	83
190	215	173	142	119	105	96	89	84	80	77
200	212	169	137	113	100	91	84	79	76	73
210	210	165	132	109	96	87	80	75	71	68
220	207	161	127	105	92	83	76	71	67	64
230	204	157	122	101	89	79	73	68	64	61
240	202	153	118	98	85	76	69	64	61	57
250	199	150	113	95	82	73	66	61	58	55
260	197	146	110	92	79	70	64	59	55	52
270	195	143	107	89	77	68	61	56	52	50
280	192	139	105	87	74	65	59	54	50	47
290	190	136	102	84	72	63	57	52	48	45
300	188	133	100	82	69	61	55	50	46	43

Table 4c — Allowable stress p_{bc} in bending (N/mm^2) for case B of Clause 19 a) 2) for grade 55 steel

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	280	280	280	280	280	280	280	280	280	280
45	280	280	280	280	280	280	280	280	280	280
50	280	280	280	280	280	280	280	280	280	280
55	280	280	280	280	280	280	280	280	280	280
60	280	280	280	280	276	274	273	272	271	270
65	280	280	279	272	267	265	263	262	261	260
70	280	280	272	264	259	256	253	252	251	250
75	280	280	266	256	250	247	244	242	241	240
80	280	277	259	249	242	238	235	233	232	230
85	280	273	253	242	234	229	226	224	222	221
90	280	268	248	235	227	221	217	215	213	211
95	280	264	242	228	219	213	209	205	203	202
100	280	260	237	222	212	205	200	197	194	192
105	280	256	232	216	205	197	192	188	185	183
110	280	252	227	210	198	190	184	179	176	174
115	280	248	222	204	191	182	176	171	167	164
120	280	245	217	198	184	175	168	162	158	155
130	280	238	208	187	172	161	152	146	141	138
140	278	231	200	177	160	147	138	131	125	122
150	273	225	191	167	148	134	124	119	115	112
160	269	219	184	157	137	123	115	110	106	103
170	265	213	176	148	127	115	108	102	98	95
180	261	207	169	140	119	109	101	95	91	88
190	258	202	162	131	113	103	95	89	95	82
200	254	197	155	123	108	97	90	84	79	76
210	250	191	149	118	103	92	85	79	75	71
220	247	186	142	114	99	88	80	75	70	67
230	243	181	136	110	94	84	76	71	66	63
240	240	177	130	106	91	80	73	67	63	60
250	237	172	124	102	87	77	69	64	60	57
260	234	167	120	98	84	74	66	61	57	54
270	231	163	117	95	81	71	64	58	54	51
280	228	159	114	92	78	68	61	56	52	49
290	224	154	111	89	75	66	59	54	50	47
300	222	150	108	86	73	63	57	52	48	45

20 Bending stresses (plate girders)

The bending stress in the extreme fibres, calculated on the effective section, shall not exceed:

1) for parts in tension, the appropriate value of p_{bt} in Table 2; and

2) for parts in compression,

a) for bending about the minor axis, the appropriate value of p_{bc} in Table 2;

b) for bending about the major axis, the least of the following:

i) the value of p_{bc} given in Table 2

ii) k_o times the value of p_{bc} given in Table 8

where $k_o = (1 + y_c/y_t) / 2$ but $k_o \leq 1$

where y_c = distance from the neutral axis of the member to the extreme fibre in compression.

y_t = distance from the neutral axis of the member to the extreme fibre in tension.

iii) the value of p_o given by the following:

for grade 43: $p_o = 220 - 0.4 d_2 / t$ N/mm²

for grade 50: $p_o = 285 - 0.6 d_2 / t$ N/mm²

for grade 55: $p_o = 350 - 0.8 d_2 / t$ N/mm²

where d_2 = twice the clear depth of web

from the compression flange to the neutral axis

and t = web

Table 8 gives values of p_{bc} corresponding to the critical stress C_s calculated as follows from the values of A and B given in Table 7 for appropriate values of D/T and l/r_y .

In Table 7:

l = effective length of compression flange (see Clause 26)

r_y = radius of gyration about the minor axis of the gross section of the whole girder, at the point of maximum bending moment

D = overall depth of girder at the point of maximum bending moment

T = mean thickness of the horizontal portions of the flanges

= sum of areas of horizontal portions, divided by the sum of their widths.

Table 7 applies to ordinary building structures with simple end connections such as end plates or cleats. Where the end connections provide less restraint, the effective length l obtained from Clause 26 shall be increased by 10 per cent.

The values of C_s given below apply to all sections with a single web.

Case I. Where the flanges are equal in size:

$$C_s = K_1 A \text{ N/mm}^2$$

Except that these values of C_s shall be increased by 20 per cent when:

T/t is not greater than 1.8

and B/T is not greater than 22

where B = overall width of girder at the point of maximum bending moment

NOTE This 20 per cent increase does not apply to castellated beams, see Clause 19 e).

In the above expression, K_1 is a coefficient which makes allowance for the reduction in thickness or breadth of flanges between points of effective lateral restraint and depends on the ratio N . The ratio N is the ratio of the flange area at the point of least bending moment to that at the point of greatest bending moment between adjacent points of effective lateral restraint. N refers *either* to the ratio of total area of both flanges *or* to the area of the compression flange only, whichever gives the smaller value of N .

Flanges should not be reduced in size to give a value of N lower than 0.2.

Values of K_1 or different values of N are given in Table 5. Values of A for different values of l/r_y and D/T are given in Table 7.

Case II. Where the flanges are unequal in size:

$$C_s = K_1 (A + K_2 B) (y_c/y_{\min}) \text{ N/mm}^2$$

where K_2 is a coefficient to allow for inequality of tension and compression flanges and depends on the ratio M . The ratio M is the ratio of the moment of inertia of the compression flange alone to the sum of the moments of inertia of both flanges, each calculated about the minor axis of the member, at the point of maximum bending moment. Values of K_2 for different values of M are given in Table 6. Values of B for different values of l/r_y are given in Table 7.

$y_{\min}$ = the lesser of y_c and y_t .

Table 5 — Values of K_1

N	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20
K_1	1.00	0.91	0.83	0.76	0.69	0.64	0.59	0.55	0.51
NOTE The values in Table 5 are obtained from: $K_1 = 1/(1.5 - 0.5N)^2$, but not greater than 1.0.									

Table 6 — Values of K_2

M	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.00
K_2	0.50	0.40	0.30	0.20	0.10	0.00	-0.20	-0.40	-0.60	-0.80	-1.00

Table 7 — Values of *A* and *B* for calculating *C_s*

where $A = \left(\frac{1675}{l/r_y}\right)^2 \sqrt{\left\{1 + \frac{1}{20} \cdot \left(\frac{lT}{r_y D}\right)^2\right\}}$
 $B = \left(\frac{1675}{l/r_y}\right)^2$

A																B
<i>l/r_y</i>	<i>D/T</i>	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
40		2 630	2 353	2 187	2 081	2 009	1 958	1 921	1 862	1 830	1 810	1 797	1 781	1 773	1 764	1 761
45		2 226	1 965	1 808	1 706	1 637	1 587	1 551	1 494	1 461	1 442	1 429	1 413	1 405	1 396	1 392
50		1 929	1 683	1 534	1 436	1 369	1 321	1 286	1 229	1 198	1 178	1 165	1 150	1 142	1 133	1 129
55		1 701	1 470	1 328	1 235	1 170	1 123	1 089	1 034	1 002	983	970	955	947	938	934
60		1 522	1 304	1 169	1 079	1 017	972	938	884	854	835	822	807	799	790	786
65		1 377	1 172	1 043	957	897	854	821	768	738	719	707	692	683	675	671
70		1 258	1 064	941	859	801	759	727	676	646	627	615	600	592	583	580
75		1 158	974	857	778	723	682	651	601	571	553	541	526	518	510	506
80		1 074	898	787	711	658	618	588	539	510	492	480	466	457	449	445
85		1 001	834	727	655	603	565	536	488	460	442	430	415	407	399	395
90		938	778	676	607	557	520	491	445	417	400	388	373	365	357	353
95		882	730	632	565	517	481	454	408	381	364	352	338	330	322	318

Table 7 — Values of *A* and *B* for calculating *C_s*

<i>l/r_y</i>	<i>D/T</i>	<i>A</i>															<i>B</i>
		8	10	12	14	16	18	20	25	30	35	40	50	60	80	100	
100		833	687	593	529	482	447	421	376	350	333	321	307	299	291	287	281
110		750	616	529	469	425	393	368	325	300	283	272	258	251	243	239	231
120		682	558	477	421	380	350	326	286	261	246	235	221	213	206	202	195
130		626	510	435	383	344	315	293	255	231	216	205	192	184	177	173	166
140		578	470	400	351	315	287	266	229	207	192	182	169	161	154	150	143
150		537	436	370	324	290	264	243	209	187	173	163	150	143	135	132	125
160		502	407	345	301	268	244	225	191	171	157	147	135	128	120	116	110
170		471	382	322	281	250	227	208	177	157	143	134	122	115	107	104	97
180		444	359	303	264	234	212	195	164	145	132	123	111	104	97	93	87
190		420	339	286	248	221	199	182	153	135	122	113	102	95	88	84	78
200		398	321	271	235	208	188	172	144	126	114	105	94	87	80	77	70
210		379	305	257	223	197	178	162	135	118	106	98	87	81	74	70	64
220		361	291	245	212	187	169	154	128	111	100	92	81	75	68	65	58
230		345	278	233	202	179	161	146	121	105	94	86	76	70	63	60	53
240		330	266	223	193	170	153	139	115	100	89	82	71	65	59	55	49
250		317	255	214	185	163	146	133	110	95	85	77	67	61	55	51	45
260		304	245	205	177	156	140	128	105	91	80	73	64	58	51	48	42
270		293	236	197	170	150	135	122	101	86	77	70	60	55	48	45	38
280		282	227	190	164	145	130	118	97	83	73	66	57	52	45	42	34
290		272	219	183	158	139	125	113	93	79	70	64	55	49	43	40	33
300		263	211	177	153	134	120	109	89	76	67	61	52	47	41	38	31