British Standard

BRITISH STANDARD

BS 4604-2:1970

Incorporating Amendment Nos. 1 and 2

Specification for

The use of high strength friction grip bolts in structural steelwork metric series —

Part 2: Higher grade (parallel shank)

UDC 621.882:624.014.2:693.81

Co-operating organizations

The committee responsible for the preparation of this British Standard consists of representatives from the following Government departments and scientific and industrial organizations:

Association of Crane Makers
Black Bolt & Nut Association of Great Britain
British Bolt, Nut, Screw and Rivet Federation
British Constructional Steelwork Association
British Steel Industry
Greater London Council
Ministry of Defence, Army Department
Ministry of Public Building & Works
Ministry of Transport, Road Research Laboratory
Individual consultants

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Contents

Foreword

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This standard makes reference to the following British Standard:

BS 4395, *High strength friction grip bolts and associated nuts and washers for structural engineering. Metric series — Part 2: Higher grade bolts and nuts and general grade washers.*

BS 3294-1[1)] gives rules for the use in structural steelwork of high strength friction grip bolts of the general grade specified in BS 3139-1[2)] Both those standards are in imperial units.

BS 4604-1[3)] similarly deals with the use of the general grade bolts specified in BS 4395-1[4)] These standards are in metric units.

This Part 2 of the standard covers the use of higher grade bolts with parallel shanks, the bolts being as specified in BS 4395-2[4)].

The use of higher grade bolts with waisted shanks will be covered by Part 3 of the standard, now in preparation.

The present Part requires that the shank tensions of the bolts be limited, by controlled tightening, to within a specified range. This limitation is due to the lower ductility of the bolt steel and the consequent risk of damage if the combined stresses from torque and tension approach the ultimate. For the same reason use is restricted to joints subject only to shear. Where joints made with higher grade bolts carry loads in the direction of the bolt axes, bolts with waisted shanks are recommended.

The design factors given are based on extensive experiments with parallel-shank bolts used with normal structural steels. Variations in them are permissible, under the engineer's authority, where the structure, the materials or other considerations demand them.

The metric values are given in SI units, details of which are to be found in BS 3763[5)] and PD 5686[6)]

[1)] BS 3294, "The use of high strength friction grip bolts in structural steelwork", Part 1, "General grade bolts".

[2)] BS 3139, "High strength friction grip bolts for structural engineering", part 1, "General grade bolts".

[3)] BS 4604, "The use of high strength friction grip bolts in structural steelwork. Metric series", Part 1, "General grade".

[4)] BS 4395, "High strength friction grip bolts and associated nuts and washers for structural engineering. Metric series", Part 1, "General grade", Part 2, "Higher grade bolts and nuts and general grade washers".

[5)] BS 3763, "International System (SI) units".

[6)] PD 5686, "The use of SI units".

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 8, 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.

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1 General

1.1 Scope

This Part of this British Standard gives rules for the use in structural steelwork of high strength friction grip bolts, with parallel shanks, of the higher grade specified in BS 4395-2[7)].

1.2 Definitions

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

1) *High strength friction grip bolts.* Bolts of high tensile steel, used in conjunction with high strength nuts and hardened steel washers, tightened to a specified shank tension so that loads can be transferred between the connected parts otherwise than by shear in or bearing on the bolts.

2) *Grip.* The total thickness of steel parts, excluding washers, to be held together.

3) *Ply.* A single thickness of steel forming part of a structural joint.

4) *Length of bolt.* The overall dimension from the underside of the bolt head to the extreme end of the shank, including any chamfer or radius.

5) *Effective interface.* A common contact surface between two load-transmitting piles, excluding any packing pieces, through which the bolt passes.

6) *Slip factor.* The ratio of the load, per effective interface, required to produce slip in a pure shear joint, to the nominal shank tension (i.e. 0·85 times proof load) induced in the bolt or bolts.

7) *Load factor.* The numerical value by which the load which would cause slip in a joint is divided to give the permissible working load on the joint.

8) *The engineer.* The person responsible for the design and satisfactory completion of the structure, as covered by this specification.

1.3 Conditions of use

The higher grade bolts which are the subject of this standard are specifically identified for a particular application with a special tightening procedure and shall not be used except in strict compliance with the following clauses.

These bolts are for use in joints subject **ONLY TO SHEAR,** and shall be tightened only by means which limit the shank tension to within the specified range.

2 Materials and dimensions

2.1 Bolts, nuts and washers

2.1.1 Dimensions and properties. The bolts, nuts and washers shall comply with the requirements of BS 4395-2[7)].

2.1.2 Storage. Care shall be taken that bolts, nuts and washers are stored in dry weatherproof conditions in such a way that they will not deteriorate. They are normally supplied by the manufacturers with a light coating of oil which is not detrimental and should not be removed. In this condition they are ready for normal use, and further treatment at works or site is not recommended.

2.2 Length of bolt

The minimum length of a bolt shall be calculated by adding to the grip the allowance given in Table 1. This allows for the thickness of one nut and one flat washer and for sufficient protrusion of the bolt end.

Where other washer arrangements are used, including taper washers as in **4.1**, appropriate additional, allowance shall be made.

[7)] BS 4395, "High strength friction grip bolts and associated nuts and washers for structural engineering. Metric series", Part 2, "Higher grade bolts and nuts and general grade washers".

Table 1 — Bolt Length Allowances

Nominal size and thread diameter	Allowance to be added to the grip
	mm
M 16	26
M 20	30
M 22	34
M 24	36
M 27	39
M 30	42
M 33	45

3 Design

3.1 Design procedure

The following design procedures depend on the tightening of every bolt to at least its minimum shank tension as given in Table 2.

3.1.1 Number of bolts. The number of bolts, and their disposition, in a joint shall be such that the resulting load at any bolt position does not exceed the value:

$$\frac{\text{slip factor}}{\text{load factor}} \times \text{number of effective interfaces} \times 0.85 \times \text{proof load of one bolt.}$$

In this expression the load factor shall be taken as 1·4 for a structure subject only to static loading, and 1·7 for a structure subject to dynamic loading. Where wind forces are taken into consideration, these load factors may be reduced to 1.2 and 1.4 respectively provided that the joints meet the requirements of the unreduced factors if the wind forces are neglected.

No additional factor is required to take account of fatigue conditions.

No additional factor is required to take account of packings within a joint.

3.1.2 Determination of slip factor. It shall be the responsibility of the engineer to determine the slip factor by a series of tests such as that recommended in Appendix A. Because of the greater clamping force obtainable with higher grade bolts, it shall not be assumed that the same slip factor will apply as for general grade bolts. The slip factor shall have the value:

$$\frac{\text{slip load}}{2 \times 0.85 \times \text{minimum proof load of one bolt} \times \text{number of bolts}},$$

where the slip load is as defined in Appendix A. The Figure 2 in the denominator takes account of the existence of two interfaces, and the factor 0·85 takes account of the restricted shank tension specified (see **4.2**) for higher grade bolts with parallel shanks.

The method of tightening the bolts in the test joints shall be the same as in the assembly of the structure.

Proof loads and shank tensions for bolts are given in Table 2.

Table 2 — Proof loads and shank tensions for bolts

Nominal size and thread diameter	Minimum proof load (BS 4395-2[a])	Shank tension	
		Minimum (0.85 × proof load)	Maximum (1.15 × proof load)
	kN	kN	kN
M 16	122.2	103.9	140.5
M 20	190.4	161.8	219.0
M 22	235.5	200.2	270.8
M 24	274.6	233.4	316
M 27	356	303	409
M 30	435	370	500
M 33	540	459	621

[a] BS 4395, "High strength friction grip bolts and associated nuts and washers for structural engineering. Metric series", Part 2, "Higher grade bolts and nuts and general grade washers".

3.2 Surfaces in contact

At the time of assembly the surfaces in contact shall be free of oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them. Tight mill scale is not detrimental.

The use of surface coatings is not precluded provided the appropriate slip factor is determined as in **3.2**.

3.3 Holes in members

All holes shall be drilled, and burrs shall be removed.

Where the number of plies in the grip does not exceed three, the nominal diameter of the hole shall be 2 mm larger than that of the bolt for bolt diameters up to 24 mm, and 3 mm larger than that of the bolt for diameters above 24 mm.

Where the number of plies in the grip exceeds three, the nominal diameter of hole in the two outer plies shall be as above; and the nominal diameter of hole in the inner plies shall be not more than 3 mm larger than that of the bolt.

Where high strength friction grip bolts are used, the deduction in cross-sectional area of connected tension members shall be in accordance with the appropriate British Standard except that, in calculating the area to be deducted, the diameter of the hole shall be used. No deduction shall be made in the case of compression members.

The distance from the centre of any hole to the edge of a member and the distance between the centres of holes shall be in accordance with the appropriate British Standard.

3.4 Minimum ply thickness

In any joint using high strength friction grip bolts no outer ply and wherever possible no inner ply, shall be less than 10 mm thick unless it can be demonstrated to the satisfaction of the engineer that any consequent limitations to the performance of the joint owing, for example, to crumpling, tearing, buckling or bending of plies, to corrosion between plies or to limited extensibility of short bolts are adequately catered for.

NOTE The problem of limited extensibility is not peculiar to the presence of thin plies but may arise with any bolt where the grip is small and where there is only a short length of thread between the bolt head and the face of the nut.

4 Assembly

4.1 General

Where plane parallel surfaces are involved, each bolt-and-nut assembly shall include one washer, placed under the bolt head or the nut, whichever is to be rotated during tightening.

The rotated bolt head or nut shall always be tightened against a surface normal to the bolt axis; this will require the use of an appropriate tapered washer where the surfaces are not parallel. Such a washer shall also be used under the non-rotated component except where the angle between bolt axis and contact surface is within the limits of 87° and 93°. Tapered washers shall be correctly positioned.

No gasket or other flexible material shall be placed between the plies. Holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely inserted. Driving of bolts is not permitted. Nuts shall be so placed that their identification marks are clearly visible after tightening.

Bolts and nuts shall always be tightened in a staggered pattern and, where there are more than four bolts in a joint, from the middle of the joint outwards. High strength friction grip bolts, nuts and washers may be used temporarily to facilitate assembly during erection of a structure; if they are so used, care shall be taken that there is no deterioration of the thread surfaces which will affect the torque-tension relation, and final tightening shall be in the correct pattern for the complete joint.

If after final tightening a bolt or nut is slackened off for any reason, the bolt, nut and washer shall be discarded and not re-used.

4.2 Method of tightening

Bolts and nuts shall be tightened to give a shank tension in the bolt of between 0·85 and 1·15 times the specified minimum proof load. The part-turn method of tightening is not permitted because of the wide range of the resulting bolt tensions.

4.2.1 Tightening by torque control. In the torque-control method of tightening the following procedure shall be adopted:

A calibrated wrench, either power-operated or hand-operated, is normally used. The torque needed to produce the specified shank tension is determined by actual site conditions.

Where there are several bolts in a joint, the wrench is re-applied to re-tighten bolts previously tightened which may have lost tension through tightening of subsequent ones, and the process is continued until all are finally tightened to the prescribed torque.

It is essential to ensure that the wrench is maintained in proper condition and calibration (see **4.3**). The recommendations of the wrench manufacturer should be obtained and followed.

4.2.2 Tightening by other means. Tightening by means other than a calibrated wrench is not precluded by this specification, provided that the shank tension attained is within the range specified in Table 2.

4.3 Calibration

The tightening equipment, whatever its type or pattern, shall be calibrated regularly at least once per shift, and more frequently if in the engineer's opinion conditions of site and usage so demand. The calibration shall consist of tightening a sample bolt (which thereafter shall not be used either for calibration or structural purposes) against a load cell or similar device capable of measuring the shank tension induced. The equipment shall be adjusted to give a shank tension 10 % higher than the minimum given in the third column of Table 2, either by the means provided in the wrench or by ancillary equipment supplied or recommended by the wrench manufacturer.

The equipment shall be re-calibrated if there is a change in the diameter of bolt being used, or if there is a change in grip length exceeding one fifth of that used for calibration.

With air-operated wrenches, where stall or cut-off is controlled by air pressure, it is recommended that a working time of 10 seconds to 15 seconds be used to attain the required shank tension. The nut shall in any case be kept in motion throughout the calibration period. The length of hose between wrench and compressor shall be the same when calibrating as when in actual use; and the length of hose between wrench and reducing valve shall be as short as possible, normally not more than 3 m. The load cell or similar device shall be checked for register and accuracy at intervals as recommended by the manufacturer.

5 Inspection

5.1 Inspection procedure

It shall be ascertained that an appropriate hardened washer has been fitted under every bolt head and nut where one is required (see **4.1**). Where a tapered washer is required it shall be of the correct taper and properly positioned.

Where the torque-control method of tightening (see **4.2.1**) has been used it shall be ascertained that the wrench has been correctly calibrated and that the proper tension has been induced in every bolt.

Whatever means of tightening has been employed, a sampling procedure is required for inspection purposes; the details must be agreed with the engineer. It is suggested that a suitable sample will consist of at least 32 bolts, selected at random from a batch such as that comprised in the daily work of one gang. The torque required to tighten these bolts further may be measured by means of a calibrated hand wrench or impact tool. If the torque for any bolt is less than that found in the calibration to be required to induce the correct shank tension, every bolt in the batch shall be examined, and tightened further if necessary. Alternatively the sample bolts may be checked by a calibrated wrench set to produce a torque 5 % in excess of that required. Such a wrench should not move the nut; if it does, every bolt shall be examined, and tightened further if necessary.

Bolts and nuts found to be in any way defective shall be discarded, and replaced by new ones.

Appendix A Test for slip factor

A.1 Form of test specimen. The form of test specimen recommended on the ground of reliability of results consists of two inner or tongue plates bolted between two cover plates (see Figure 1). Care should be taken that the inner plates used are the same in thickness; this can be ensured by cutting them consecutively from the same piece of material and assembling them in the original relative positions. The longitudinal axis of the specimens should be in the direction of rolling of the material. Care should be taken in setting up the specimen to ensure that the bolts are not already in bearing.

The tests should be done with not less than two bolts on each side of the joint for each thickness of plate. Not less than three tests should be made for each type of joint. The dimensions of the plate should be such that the stress does not reach the yield point of the material. The size of the plates used in a test to determine slip factor is governed principally by the capacity of the testing machine available. Attention is drawn to the limits of outer ply thickness in **3.4**.

A.2 Time of testing. At least 18 h should preferably elapse after the completion of the tightening of the bolts in the test specimen, before it is tested. In exceptional circumstances the specimen may be tested after 2 h and the slip load to be assumed in determining the slip factor shall be taken as 95 % of the test result.

A.3 Rate of loading. The load should be applied at a uniform rate of approximately 50 kN/min provided that slip does not occur in less than 3 min.

A.4 Slip load. The slip load shall be taken as the load required to produce a displacement between adjacent points in an inner plate and a cover plate, in the direction of the applied load, in the plane of the effective interfaces of the joint of at least 0·1 mm. The slip load used for determining the slip factor should be taken as the least of the three or more test results obtained, except that if in the opinion of the engineer one result is unrepresentative, a further series of tests may be carried out.

NOTE The characteristics of some finishes may cause a slip of more than 0·025 mm at the working load (which is 0·7 of the slip load). The engineer should take note of this and make such adjustment to the slip factor as he considers necessary for the application concerned.

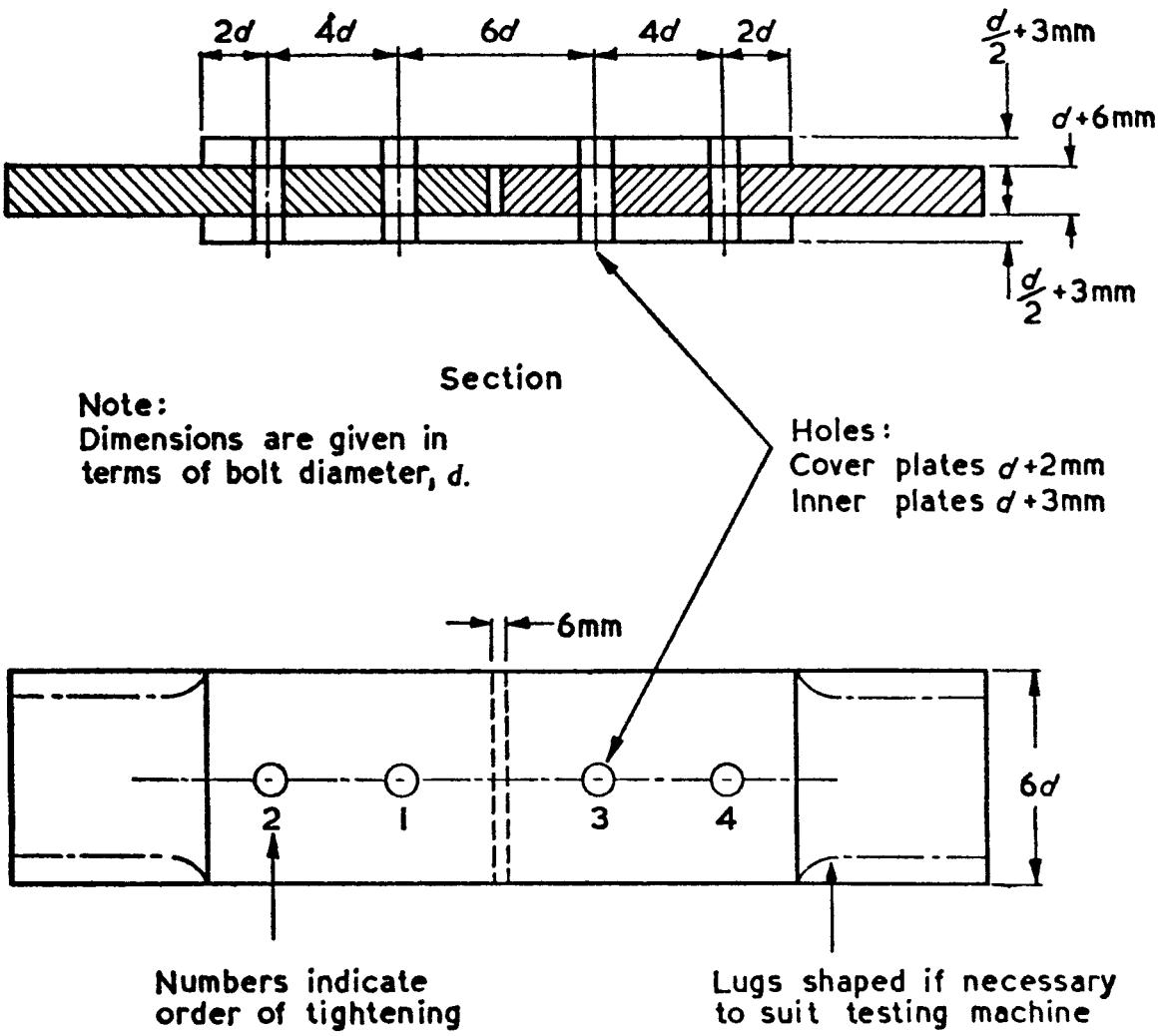

Figure 1 — Typical test specimen

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