

Spacers and chairs for steel reinforcement and their specification —

Part 1: Product performance requirements

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Committees responsible for this British Standard

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Foreword

This British Standard has been prepared by Technical Committee B/525/2. It is the first edition of the standard.

Until now the inadequate manufacture and use of spacers and chairs and method of tying has been a major cause of misplaced steel reinforcement resulting in decreased durability of reinforced concrete. In November 1989 the Concrete Society published *Spacers for reinforced concrete* (CS101) [1] providing recommendations for achieving cover but until now no British Standard has existed.

All British Standards for reinforced concrete design and construction (e.g. BS 8110-1, BS 5400-7 and BS 8007) state that the nominal cover specified applies to all reinforcement including links.

This British Standard gives standardized performance requirements for and methods of testing spacers and chairs. It is based on Concrete Society Report CS 101 "Spacers" [1] published in November 1989 and was developed to be consistent with the Comité Euro-International du Béton Bulletin d'Information No. 201 *Spacers, chairs and tying of steel reinforcement* [2].

Performance and testing requirements are based on tests carried out on the capacity of spacers and chairs which have been available in the UK for many years and which have proved to be satisfactory in use.

It is imperative that chairs and spacers conforming to BS 7973-1 are applied in accordance with BS 7973-2.

Abnormal loads, such as those exerted by construction plant, storage of materials and heavy reinforcement cages, can overload spacers and chairs. Under abnormal load conditions adequate support is most suitably achieved using heavy (H) category line spacers at centres which depend on the exact size and nature of the load.

Annex A is normative.

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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

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1 Scope

This part of this British Standard specifies product performance requirements for spacers and chairs sufficient to achieve and maintain cover to reinforcement in in situ reinforced concrete members subject to normal construction loads when used in accordance with BS 7973-2.

NOTE Where appropriate, the basic principles can be applied to precast concrete or proprietary systems.

Product requirements for spacers and chairs include their dimensions, identification, point load strength, permanent deflection after loading, stability and fixity.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 1881-108, *Testing concrete — Part 108: Method for making test cubes from fresh concrete*.

BS 1881-111, *Testing concrete — Part 111: Method of normal curing of test specimens (20 °C method)*.

BS 1881-116, *Testing concrete — Part 116: Method for determination of compressive strength of concrete cubes*.

BS 4482, *Specification for cold reduced steel wire for reinforcement of concrete*.

BS 4483, *Steel fabric for the reinforcement of concrete*.

BS 7973-2, *Spacers and chairs for steel reinforcement and their specification — Part 2: Fixing and application of spacers and chairs and tying of reinforcement*.

BS 8110-1:1997, *Structural use of concrete — Part 1: Code of practice for design and construction*.

3 Terms and definitions

For the purposes of this British Standard the following terms and definitions apply.

3.1

cover

distance between the steel reinforcement and the nearest face of the concrete

NOTE 1 Cover, or nominal cover, is the cover specified by the structural designer on the structural design drawings.

NOTE 2 As the term “minimum cover” can be confused with “nominal cover”, it should not be used.

3.2

spacer

component which is placed to maintain cover between the reinforcement and formwork or blinding and which provides cover or support for reinforcement at a single point on one or more faces of the formwork or blinding

NOTE As stated in BS 8110-1:1997, Table 3.4, 15 mm cover spacers may only be used where the nominal maximum size of aggregate does not exceed 15 mm.

3.3

end spacer

spacer designed to fit on the ends of reinforcement to provide end cover

3.4

line spacer

spacer normally made of either plastics or cementitious bars, normally of constant cross-section, used to support horizontal layers of reinforcement or horizontal continuous steel chairs

3.5

rib spacer

spacer used where there are no links within the ribs and which are designed to support one or more main bars in hollow pot, waffle, trough and ribbed slabs and to provide spacing between the sides of the hollow pot, waffle, trough and rib forms

3.6

wheel spacer

spacer having a circular section, perpendicular to the bar to which it is attached, used for maintaining cover in vertical members to the reinforcement nearest the surface of the concrete

3.7

clip-on spacer

spacer in which the clip action is an integral part of the design of the spacer

NOTE A clip-on spacer is usually made of plastics.

3.8

wire-on spacer

spacer that is attached to the bar by the use of tying wire

NOTE Wire-on spacers are usually cementitious.

3.9

chair

component in sizes of 50 mm to 300 mm normally manufactured from steel wire conforming to BS 4482 commonly used to support top horizontal reinforcement or to separate vertical reinforcement in walls

NOTE Chairs may be individual, continuous, or circular. Chair heights above 300 mm are normally scheduled using bent bar reinforcement.

3.10

individual chair

chair manufactured in standard heights of between 75 mm and 300 mm inclusive and used to support reinforcement at one point

3.11

continuous chair

chair manufactured to provide a straight line of support at a uniform height normally in the range of 45–300 mm

NOTE Continuous chairs are generally available in continuous lengths of up to 2 000 mm.

3.12

circular chair

steel chair delivered flat and formed into circles on site

3.13

welded fabric

cross-over arrangement of longitudinal wires and cross wires that are welded together at the cross-over points in a shear resistant manner, conforming to BS 4483

4 Designations and symbols

The following designations and symbols are used throughout this British Standard.

- c** Cover or nominal cover.
- d** The nominal size of the bar nearest the surface of the concrete including links, used to determine the frequency of spacers along the bar to which they are fixed. For the spacing of chairs, *d* is the nominal size of the bar or wire that the chair is supporting.
- D** The nominal size of the main bar.

5 Spacers and chair categories and applications

Spacer and chair categories required for particular applications shall be in accordance with Table 1. Criteria for assessing the spacer category shall be in accordance with Table 2.

Table 1 — Applications for spacers and chairs in terms of category

Spacer and chair category	Application
Light (L)	To provide cover in vertical members to the reinforcement nearest the surface of the concrete or to horizontal reinforcement in small sections not subject to any foot traffic. Not suitable for reinforcement greater than 16 mm in size.
Normal (N)	To provide cover to reinforcement where the size of reinforcement is 20 mm or less.
Heavy (H)	To provide cover to reinforcement where the size of reinforcement is greater than 20 mm.
Chairs (C)	To support the top reinforcement in slabs, so as to provide the required top cover or to separate layers of reinforcement.

6 General requirements for spacers and chairs

6.1 Materials of manufacture

Spacers and chairs shall be manufactured from three basic materials: plastics, cementitious material or steel wire.

The material of manufacture shall have an equivalent durability when it is in place to that of the concrete itself.

NOTE It is important that the spacer or chair does not cause any deterioration to the reinforcement or the concrete, including not allowing free passage of water to the reinforcement nor causing spalling of the finished face.

6.2 Requirements for non-cementitious spacers

Non-cementitious spacers shall satisfy the condition that any cross-section perpendicular to the bar has at least 25 % voids within the enclosed perimeter.

6.3 Requirements for cementitious spacers

The mix used for cementitious spacers shall have a cube strength of at least 50 N/mm² at 28 days when cast, cured and tested in accordance with BS 1881-108, BS 1881-111, and BS 1881-116 respectively.

In accordance with BS 8110-1 concrete spacers shall not be made on the construction site.

6.4 Requirements for steel chairs

When steel chairs are required to support reinforcement off an exposed face, the ends of each chair leg shall be encased in a protective tip, such as a closed plastics sleeve, for a distance of at least 40 mm.

Continuous and circular chairs shall comprise top and bottom wires of equal size and quality to which shall be welded transverse or lattice wires to space them.

NOTE 1 If the chair is higher than 150 mm, strengthening may be required to meet the performance requirements of this British Standard.

NOTE 2 The performance requirements of this British Standard are based on the use of 2 m lengths formed into circles of 570 mm diameter used to support the welded fabrics specified.

7 Dimensions

7.1 Preferred spacer and chair dimensions

The standard range of spacers shall be for nominal covers from 15 mm to 75 mm in 5 mm increments. The standard range of chairs shall be for heights of 75 mm to 200 mm.

NOTE As stated in BS 8110-1:1997, Table 3.4, 15 mm cover spacers may only be used where the nominal maximum size of aggregate does not exceed 15 mm.

7.2 Dimensional tolerances for spacers

The tolerance on the spacer dimension providing the cover shall be ± 1 mm for covers/heights up to 75 mm and ± 2 mm for larger cover/heights over 75 mm.

7.3 Dimensional tolerances for chairs

The tolerance on the chair dimensions providing the cover or the specified height shall be ± 2 mm.

For continuous and circular chairs where the nominal cover dimension is provided by a longitudinal element any side-supporting element shall not protrude beyond the longitudinal element by more than 3 mm.

7.4 Identification of the cover dimensions

The nominal cover dimension of the spacer shall always be displayed on its packaging. Wherever possible, as part of the manufacturing process, the nominal cover dimension shall be indicated on the actual spacer.

NOTE Single cover spacers are recommended.

The maximum number of covers on each spacer shall be two with the value and orientation clearly marked on the actual spacer.

7.5 Wire-on spacers

The dimension of a wire-on spacer at its base shall be at least 20 mm measured in the direction of the bar which it is supporting and at least 0.75 of the cover dimension perpendicular to the bar.

7.6 Clip-on spacers

As clip-on spacers have varying dimensional requirements relating to their fixity, they shall conform to clause 8.

7.7 Chairs

7.7.1 The distance between any two legs of an individual chair shall be not less than 0.5 of the specified height of the chair.

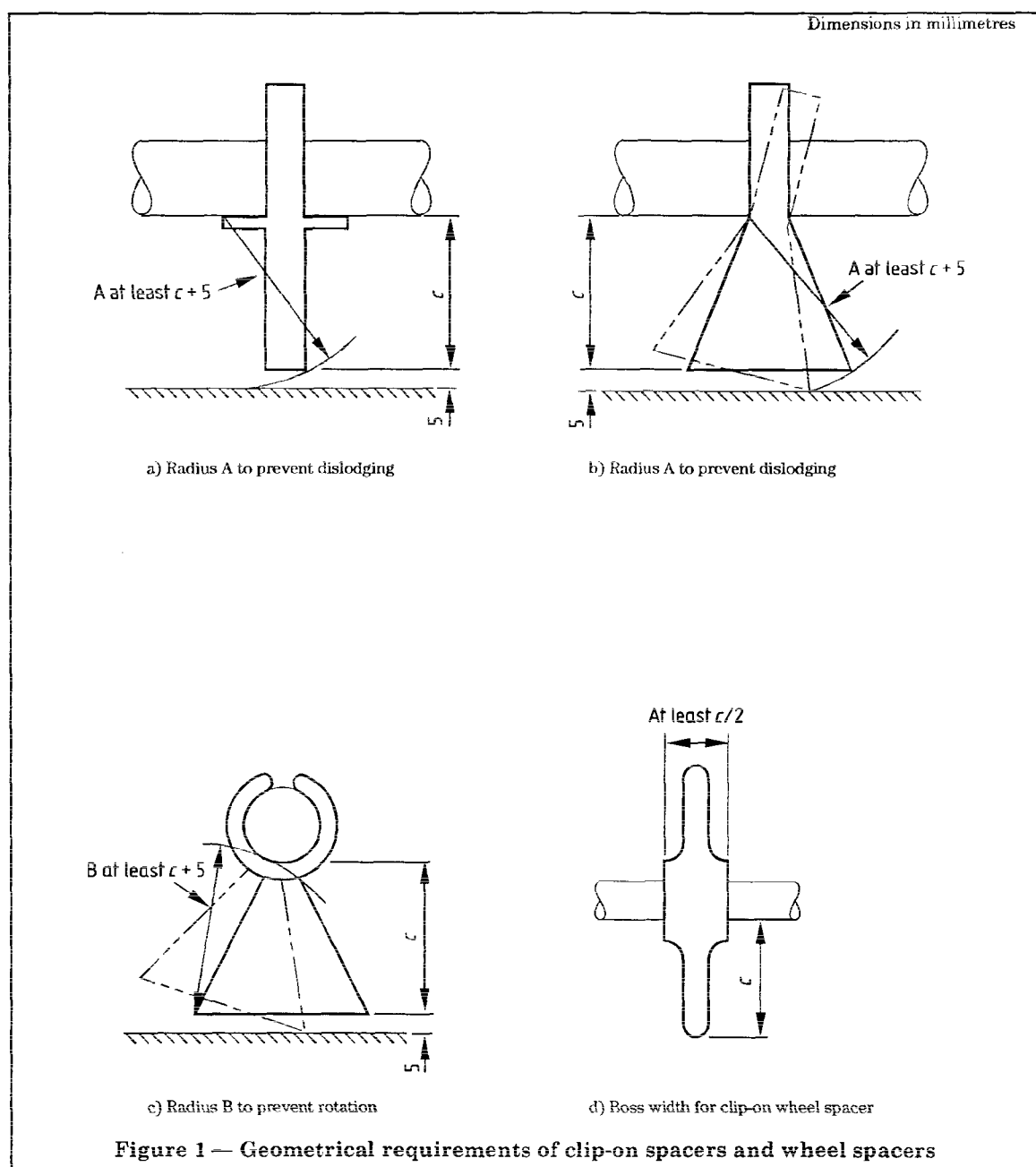
7.7.2 The distance between the two rows of supports of a continuous chair shall be not less than 0.5 of the specified height of the chair.

8 Stability

8.1 The stability of a clip-on spacer, other than a clip-on wheel spacer, shall be provided by having a radius of rotation at least 5 mm greater than the required cover, both perpendicular and parallel to the line of the reinforcing bar to which it will be attached.

NOTE The radius of rotation is illustrated in Figure 1.

8.2 Clip-on wheel spacers do not require a minimum radius of rotation perpendicular to the bar as stability is provided by the boss bearing length parallel to the bar which shall be greater than half of the required cover, as shown in Figure 1.



9 Load bearing capacity

The point load which each spacer or chair shall support within an allowable deflection shall be in accordance with Table 2, when measured in accordance with the method of test given in Annex A. The maximum allowable permanent deflection shall be 1 mm for spacers and chairs.

10 Fixity

10.1 Wire-on spacers and chairs

Wire-on spacers and chairs shall be tied to the reinforcement with tying wire to achieve fixity.

10.2 Clip-on spacers

Fixity of clip-on spacers shall be verified by observing whether they prevent a $0.5 \text{ kg} \pm 0.01 \text{ kg}$ commercially ground, unrusted, degreased, silver steel bar, of the smallest bar size (in the size range produced by the manufacturer) from sliding vertically through the spacer as shown in Figure 2. In addition, clip-on spacers shall not require more than 150 N force to place them on the largest bar size in the size range produced by the manufacturer (at $20^\circ\text{C} \pm 2^\circ\text{C}$).

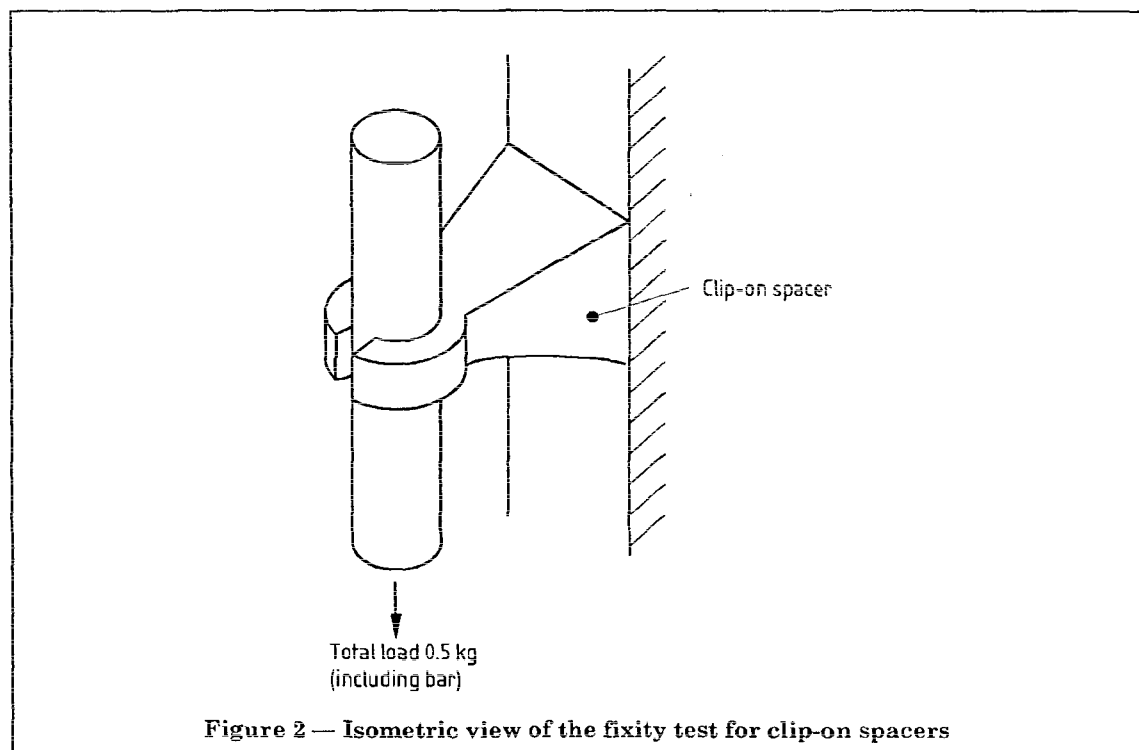


Table 2 — Point test load for spacers and chairs

Component	Category	Typical types ^a	Cover/height mm	Test load kN	Figure and clause number
Spacers	Light (L)	Clip-on wheel	15 ^b –50	0.25	Figure A.1 A.1
		Clip-on	15 ^b –50		
		End	15 ^b –50		
	Normal (N)	Clip-on	15 ^b –75	0.50	
		Wire-on	15 ^b –75		
		Line	15 ^b –40		
		Rib	15 ^b –45		
	Heavy (H)	Wire-on	25–75	3.00	
		Line	25–50		
Rib		25–75			
Chairs	(C)	Individual ^{c d e}	75–300	1.00	Figure A.3 A.2
	(C)	Continuous ^{c d e}	50–300	1.00 at nodes 0.50 at mid-nodes	
	(C)	Circular ^{d e}	50–180	1.00 at nodes 0.20 at mid-nodes	

^a Heavy category spacers are currently cementitious and providing they pass a test load of 3.0 kN in compression they may be considered for all applications. Light and normal category spacers are generally made of plastics. Chairs are at present made of steel wire. Other spacers or chairs made of suitable robust, inert, durable and impervious materials which satisfy the above performance requirements may also be used.

^b As stated in BS 8110-1:1997, Table 3.4, 15 mm cover spacers may only be used where the nominal maximum size of aggregate does not exceed 15 mm.

^c For use with bars or welded fabric (with wires at least 6 mm at centres not exceeding 200 mm, or for C type fabrics with wires at least 7 mm size resting on the chairs). Tests in accordance with A.2 have shown that these loads are achieved using material conforming to BS 4482 with 5 mm top wires and suitable cross or lattice wires at 200 mm node centres and suitable bottom wires and also with 3.5 mm top wires with nodes at 100 mm centres and suitable bottom and cross or lattice wires.

^d For use in slabs with suitable A, B and C type welded fabrics conforming to BS 4483. For circular chairs used with A and B type fabrics, these test criteria are based on 570 mm diameter circles with centres at each apex of an equilateral triangle of side 1 200 mm (i.e. 1 200 mm in one direction and 1 040 mm in the direction at right angles with rows staggered).

^e Fabric types A98, B196 and C283 are not suitable for supporting foot traffic. Specifications for the layout of continuous and circular chairs can be found in BS 7973-2.

11 Marking

Each package of spacers or bundle of chairs shall have at least one identification mark on it which shall be the nominal cover in millimetres.

Spacers providing one value of nominal cover shall, wherever possible as part of the manufacturing process, be marked with the nominal cover dimension.

Spacers providing more than one nominal cover shall be clearly marked with all the nominal covers in millimetres. These marks shall be on the spacer either at the point where the spacer supports the reinforcement or adjacent to the appropriate cover. In the latter case the mark shall be upright when the indicated nominal cover is being provided.

The spacer category in accordance with Table 1, the number of this British Standard and the nominal cover shall be marked on the bag, box or other packaging in which the spacers are supplied¹⁾.

EXAMPLE:

H – BS 7973-1:2001 – 40 mm.

¹⁾ Marking BS 7973-1:2001 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

12 Inspection and testing

12.1 Initial product type testing

Spacers and chairs shall be subject to the following type tests:

- a) load, deflection and recovery test in accordance with Annex A;
- b) stability test in accordance with 7.7 (chairs only);
- c) fixity test (clip-on spacers only) in accordance with 10.2.

Five samples of each spacer/chair type, representing the smallest and largest in the available range, shall be selected at random and subject to the tests in a) to c).

All samples shall meet the specified criteria in A.1 or A.2. Where one or more samples fail to meet the specified criteria that spacer/chair type shall be deemed not to conform to this standard.

12.2 Product inspection during manufacture

The manufacturer shall identify, document and monitor the key variables in the production process, for example:

- a) the type and size of spacer/chair;
- b) the sources and specification of components and materials;
- c) the dimensions of the spacer relevant to cover and stability, to the nearest 0.1 mm.

12.3 Product testing during manufacture

The manufacturer shall undertake testing in accordance with 12.1 when any of the key variables change.

All samples shall meet the specified criteria in A.1 or A.2. Where one or more samples fail to meet the specified criteria that batch of spacers/chairs shall be deemed not to conform to this standard.

NOTE *Assessed capability.* Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in BS EN ISO 9000 series, by an accredited third-party certification body.

12.4 Inspection and test records

The inspection and test records shall be traceable to specific production dates and batches.

Inspection and test records shall be made available on request and be retained for a period of 24 months after delivery.

Annex A (normative)

Load testing

A.1 Load testing spacers

A.1.1 Principle

A spacer is placed in its working position on a flat gauge plate. A load is applied and the total deflection is measured and recorded.

A.1.2 Apparatus

A.1.2.1 Load application and deflection measurement apparatus, comprising a dry, clean, commercially ground flat gauge plate, a balance counterweight, a loading bar and a deflection gauge (see Figure A.1).

A.1.2.2 Ground silver steel loading bar, for testing plastics spacers, whose dimensions are equal to the smallest and largest reinforcement bar for which the spacer is designed.

A.1.2.3 8 mm plain round bar, for testing cementitious spacers.

A.1.3 Procedure

A.1.3.1 General

Place each spacer in its working position on the flat gauge plate.

A.1.3.2 Plastics spacers

Test plastics spacers at $-5\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and $30\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. Load plastics spacers in turn with the ground silver steel loading bar. Load clip-on plastics wheel spacers with the opening for the bar at all possible working positions within the upper half of the spacer (see Figure A.2).

Apply the load, as specified in Table 2, in less than 10 s. The load shall remain applied for a further 10 min.

Under applied load, measure and record the total deflection. Remove the test load.

1 min after removal of the test load, the height of the spacer shall be within 1 mm of its height before loading.

A.1.3.3 Cementitious spacers

Continuously immerse cementitious spacers in water for seven days prior to load testing. Test cementitious spacers at a temperature of $+20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. Load cementitious spacers with an 8 mm plain round bar.

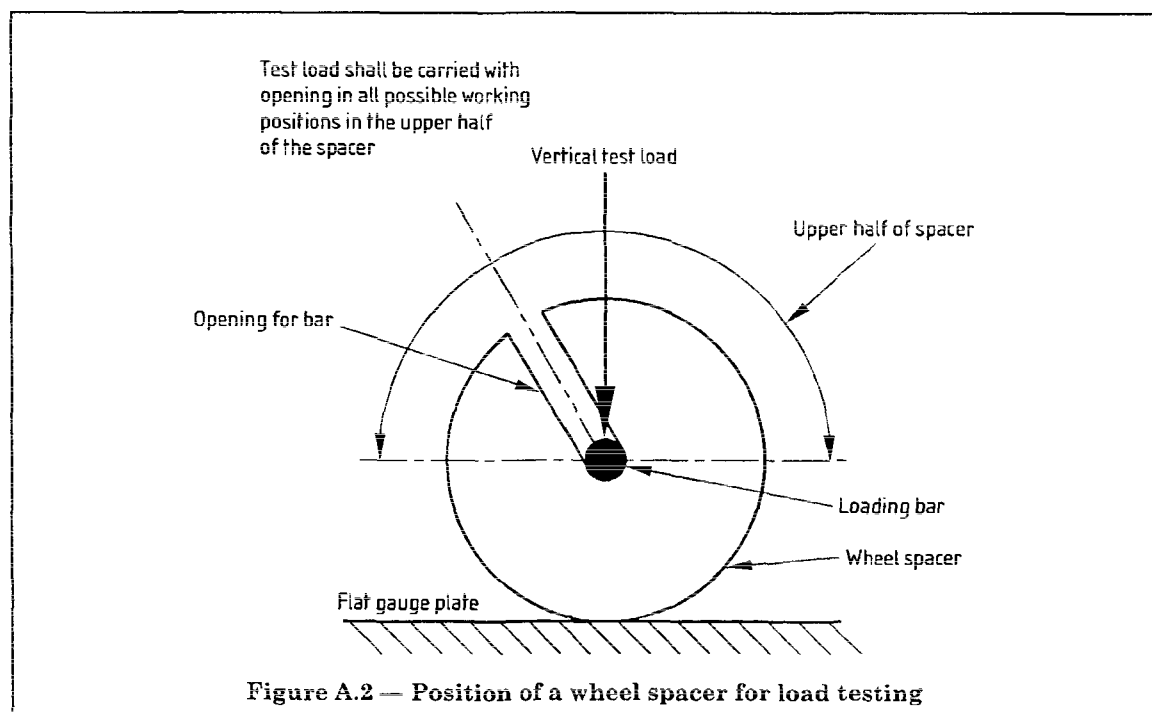
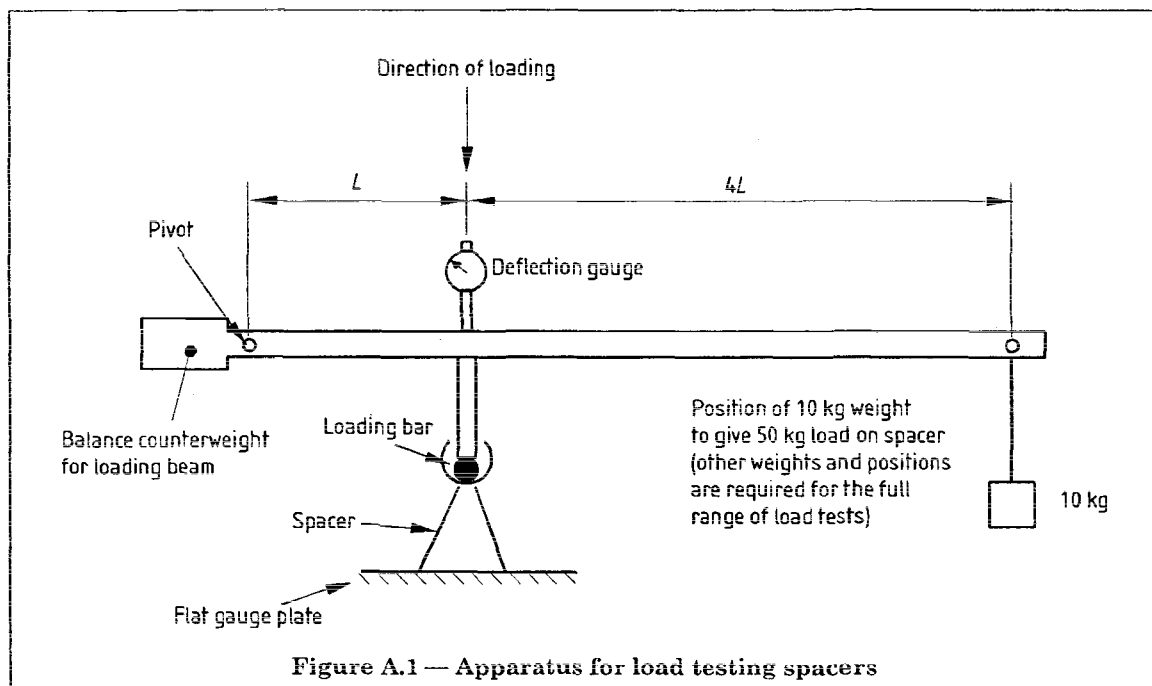
Apply the load, as specified in Table 2, in less than 10 s. The load shall remain applied for a further 10 min.

Under applied load, measure and record the total deflection. Remove the test load.

1 min after removal of the test load, the height of the spacer shall be within 1 mm of its height before loading.

After testing cementitious spacers shall show no visible sign of cracking.

NOTE Local surface spalling under the bar is acceptable.



A.2 Point load testing chairs

A.2.1 Principle

A chair is placed in its working position on a flat gauge plate. A load is applied and the total deflection is measured and recorded.

A.2.2 Apparatus

A.2.2.1 Load application and deflection measurement apparatus, comprising a dry, clean, commercially ground flat gauge plate, a balance counterweight, a loading bar and a deflection gauge (see Figure A.3).

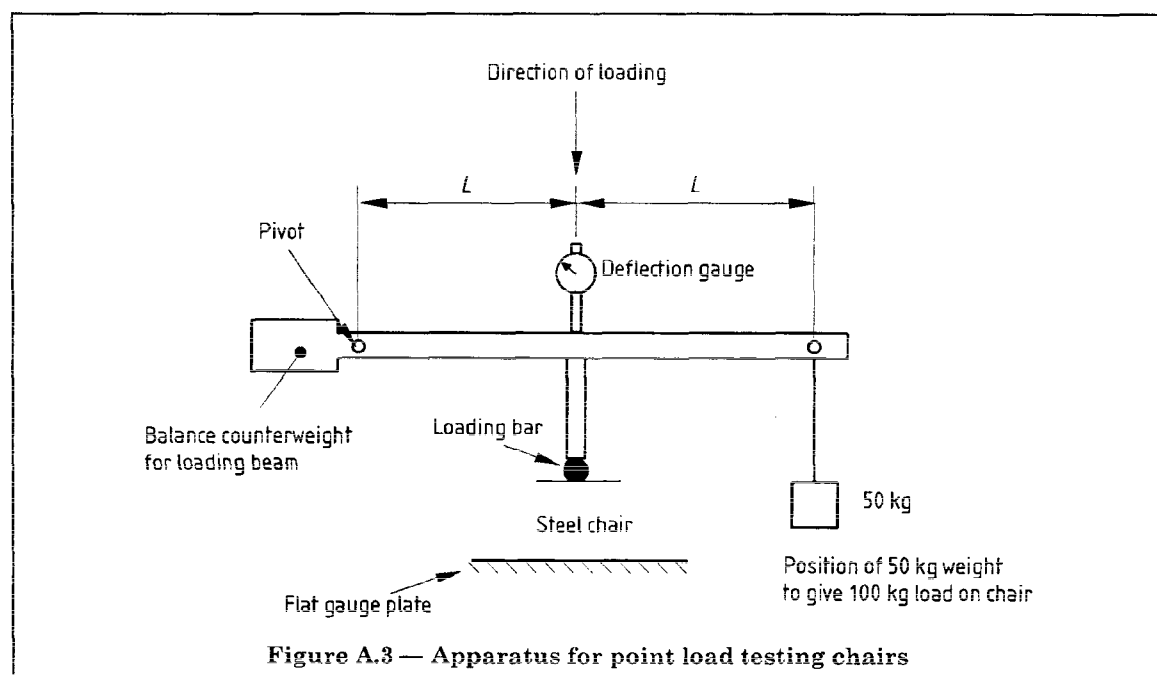
A.2.3 Procedure

Place each chair in its working position on the flat gauge plate. Continuous and circular steel chairs shall be loaded both at a node point and a mid-node point.

Apply the load, as specified in Table 2.

Under applied load, measure and record the total deflection. Remove the test load.

Under the loads specified in Table 2 the permanent deflection shall not exceed 1 mm. If protective tips are present at the bottom of the steel chairs they shall not fracture or puncture during the test loading.



Bibliography

Standards publications

BS 5400-7:1978, *Steel concrete and composite bridges — Part 7: Specification for materials and workmanship, concrete reinforcement and prestressing tendons*.

BS 8007:1987, *Code of practice for design of concrete structures for retaining aqueous liquids*.

BS EN ISO 9000 (all parts), *Quality management systems*.

Other documents

[1] CONCRETE SOCIETY. *Spacers for reinforced concrete*. Crowthorne [Berkshire]: Concrete Society, 1989 Report CS101²⁾.

[2] COMITÉ EURO-INTERNATIONAL DU BÉTON. *Bulletin d'Information No. 201 — Spacers, chairs and tying of steel reinforcement*. Lausanne: Comité Euro-International du Béton, 1990³⁾.

²⁾ Available from: The Concrete Society, Century House, Telford Way, Crowthorne, Berks RG45 2YS.

³⁾ Available from: Comité Euro-International du Béton, Office DGC-A2-424, Swiss Federal Institute of Technology Lausanne (EPFL), Case Postal 88, CH-1015 Lausanne, Switzerland.

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