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PUBLISHED DOCUMENT

Structural bearings – Guidance on the use of structural bearings

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Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 26, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document is published by BSI and came into effect on 31 August 2009. It was prepared by Technical Committee B/522, *Structural bearings*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

This Published Document gives non-contradictory complementary information and additional guidance for use in the UK with BS EN 1337 (all parts), *Structural bearings*.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The provisions in this Published Document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a Published Document cannot confer immunity from legal obligations.

0 Introduction

When there is a need for guidance on a subject that is not covered by a European Standard, a country can choose to publish documents that contain non-contradictory complementary information that supports the European Standard.

Where BS EN 1337 (all parts) refers to Eurocodes, the Eurocodes (BS EN 1990 to BS EN 1999 inclusive) once published are deemed to include their UK National Annexes.

Eurocodes apply to design, not to assessment. Where bearings are required to be replaced on an existing highway structure, their capacity may, with the agreement of the overseeing organization, be chosen to accommodate the assessment loading based on UK assessment standard BD 21, *The assessment of highway bridges and structures* [1], with appropriate partial factors of safety for loading.

Attention is drawn to the requirements in BS EN 1337 (all parts) of CE marking under the Construction Products Directive [2] enabling bearings to be legally placed on the market in any EU Member State.

The requirements of BS EN 1337 (all parts) are augmented by BS EN 1993-2:2006, Annex A.

The requirements of BS EN 1337-10 are to be implemented in accordance with the Highways Agency's *Inspection manual for highway structures* [3].

1 Scope

This Published Document contains non-contradictory complementary information and additional guidance for use in the UK with BS EN 1337 (all parts). It covers the design, testing and installation of structural bearings.

In addition to those bearings covered by BS EN 1337, this Published Document gives guidance on knuckle and leaf bearings and composite roller bearings.

*NOTE Annex A gives a typical bearing schedule, which has been extended from that given in BS EN 1337-1:2000, **B.1**, to cover UK practice.*

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 3416, *Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water*

BS 5350-A1, *Methods of test for adhesives – Part A1: Adherend preparation*

BS 5400-2, *Steel, concrete and composite bridges – Part 2: Specification for loads*

BS 6949, *Specification for bitumen-based coatings for cold application excluding use in contact with potable water*

BS EN 1011-4, *Welding – Recommendations for welding of metallic materials – Part 4: Arc welding of aluminium and aluminium alloys*

BS EN 1337-1:2000, *Structural bearings – Part 1: General design rules*

BS EN 1337-2:2004, *Structural bearings – Part 2: Sliding elements*

BS EN 1337-3:2005, *Structural bearings – Part 3: Elastomeric bearings*

BS EN 1337-4, *Structural bearings – Part 4: Roller bearings*

BS EN 1337-5, *Structural bearings – Part 5: Pot bearings*

BS EN 1337-6, *Structural bearings – Part 6: Rocker bearings*

BS EN 1337-7, *Structural bearings – Part 7: Spherical and cylindrical PTFE bearings*

BS EN 1337-8, *Structural bearings – Part 8: Guide bearings and restraint bearings*

BS EN 1337-9, *Structural bearings – Part 9: Protection*

BS EN 1337-10, *Structural bearings – Part 10: Inspection and maintenance*

BS EN 1337-11:1997, *Structural bearings – Part 11: Transport, storage and installation*

BS EN 1464, *Adhesives – Determination of peel resistance of high-strength adhesive bonds – Floating roller method*

BS EN 1600, *Welding consumables – Covered electrodes for manual metal arc welding of stainless and heat resisting steels – Classification*

BS EN 1990:2002+A1:2005, *Eurocode – Basis of structural design*

BS EN 1993-1-8, *Eurocode 3: Design of steel structures – Part 1-8: Design of joints*

BS EN 10204:2004, *Metallic products – Types of inspection documents*

3 Terms and definitions

For the purposes of this Published Document, the terms and definitions given in BS EN 1337 (all parts) apply.

4 Design

4.1 Function

To achieve the required degree of freedom in the function of a specific bearing, it might be necessary to combine the characteristics of different types of bearing, the resultant bearing as a whole providing the required movements and load resistance, e.g. a plane sliding bearing, to allow translation, combined with a pot bearing, to provide for rotation.

4.2 Durability

Bearings should be detailed to exclude crevices, which allow moisture and dirt to be trapped. Skirts should be provided where specified by the overseeing organization, but the requirements of BS EN 1337-9 should not be modified as a result of skirt provision.

4.3 Uplift

If uplift can occur, bearings and their fixings should limit separation of the components to a value agreed with the overseeing organization and should resist the consequent forces. (See also BS EN 1337-1:2000, **A.1**, second list point.)

4.4 Loads and load effects

4.4.1 Compatibility with an existing structure

To ensure compatibility with an existing structure, replacement bearings should resist the loads and load effects specified in BS 5400-2 or the assessment-loading standard required by the overseeing organization and, where applicable, the effects of creep, shrinkage and pre-stress. Due allowance should be made for any eccentricities and specified dimensional tolerances in the application or distribution of loading.

The design loads Q^* on the bearings should be the nominal loads multiplied by the appropriate values of γ_{fL}, all as specified in BS 5400-2. Design load effects S^* at the serviceability limit state (SLS) and ultimate limit state (ULS) should be obtained by multiplying the effects of the design load Q^* by γ_{f3}. Values of γ_{f3} should be taken as 1.0 for the SLS and 1.1 for the ULS unless otherwise stated.

4.4.2 Restraints against translation

Where restraints are provided on bearings to resist translational movements, they should be designed to resist either the design load effects or 5% of the permanent vertical design load on the bearing, whichever is the greater.

If restraint against translation (resistance to a horizontal force) is to be shared by several bearings, consideration should be given to:

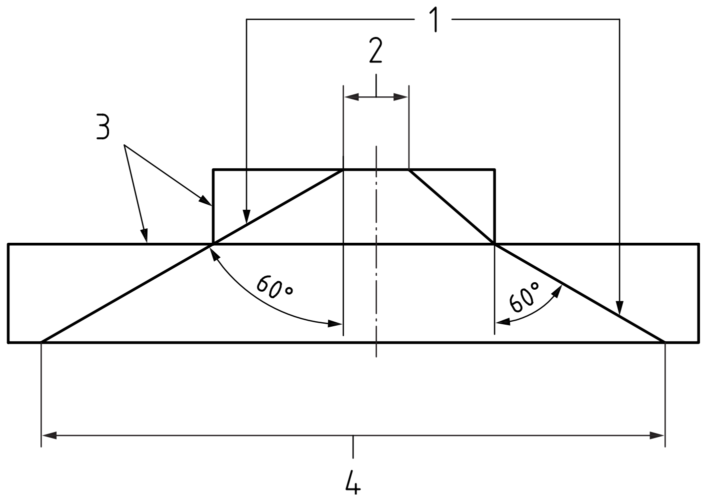
- the effects of any clearance between working parts of the bearings and their guides during their service life; and
- the effects of the stiffness of the structure on the distribution of the resulting loads between the bearings. (See also BS EN 1337-1:2000, **7.1.4**.)

4.4.3 Proportions of bearing plates

The bearings should be so proportioned that concentrated loads are distributed to ensure that the permissible pressures on the adjacent bridge structure are not exceeded.

The effective area for distributing the load may be taken as that between uninterrupted dispersal lines drawn from the bearing contact area at a maximum of 60° to the line of application of the bearing reaction (see Figure 1). Where the adjacent structure is likely to deform significantly under load, the interaction of the structure and the bearing should be considered in the design of both. (See also BS EN 1337-2:2004, **6.9**.)

Figure 1 **Load distribution**



Key

1 Uninterrupted dispersal lines

2 Contact area

3 Outer bearing or spreader plates

4 Effective area

4.5 Tolerances

NOTE Tolerances given in this document are suitable for bearings in normal use. In special circumstances of unusual loading or movement, different tolerances might be necessary.

The tolerances in **10.3** should be drawn to the attention of fabricators providing plates.

Tolerances for holes for fixing bolts should be related to the function of the bolts and the likely conditions prevailing at the time of installation of the bearings. As a guide, holes for fixing bolts or locating devices should be ±1 mm from the positions shown on the design drawings. Their diameter should be 2 mm larger than the nominal diameter of the bolt or locating key for fixing bearings to steel or precast concrete members, and 3 mm larger than the nominal diameter of bolt or shear key for replacement. For bolts or locating devices required to resist horizontal forces in shear, a close tolerance fit might be necessary.

The effects of variation in dimensions within the permitted tolerances of the bearing, including those of spacer, spreader and taper plates above and below the bearings, should be considered in the design of bearings, their connections and the associated structure.

5 Structural design considerations

5.1 Positioning of bearings

The position of bearings should be such that they are able to operate as assumed in the design of the structure. Any secondary effects resulting from either eccentric loading or movement not truly along a major axis of the bearing should be taken into account in the design of the bearing and surrounding structural elements.

Bearings should be located so as to avoid the accumulation of dirt and debris likely to interfere with their performance and the structure detailed so that water is prevented from reaching the bearings.

Space should be provided around bearings to facilitate their inspection and maintenance. Consideration should be given in the design of the structure to the means of access to the bearings.

5.2 Use of different types of bearing

When bearings with differing characteristics are used on the same line of support, the resulting interactive effects should be considered both in the design of the bearings and the structure.

NOTE Here, the "same line of support" is normally taken to mean transverse to the span direction.

5.3 Provision for resetting and replacement of bearings (BS EN 1337-1:2000, 7.6)

Facilities for correcting the effects of any differential settlement and tilt should be provided in the design of the structure, e.g. by providing jacking points, unless the structure has been designed to accommodate such effects.

A strategy for bearing replacement should be devised at the design stage of the structure, including any load restrictions required, and incorporated in the maintenance manual. The design should allow for live loading to be taken by the propped structure. In some instances it might be necessary to limit traffic during jacking but once the jacks are locked off, or supports installed, the bridge can be fully opened. The strategy should include the capacity and dimensions of jacks required and the provision, where necessary, of temporary guide and/or restraint bearings during bearing replacement.

The structure should be capable of being lifted sufficiently to permit bearing replacement without the need to break out concrete to remove or replace holding down bolts. Provision should be made for jacking points of adequate size, strength, separation, accessibility and safety on the substructure and superstructure. Separation between jacking points should allow for the provision of sliding plates combined with the jacks, where required. Anchorage points for temporary guides and restraints should also be provided, as necessary.

Jacking is not covered in BS EN 1337 (all parts). Typical aspects to be addressed include ensuring that:

- the jacks exert acceptable pressures on horizontal surfaces;
- jacking loads are adequately distributed across the structure;
- deck joints are not damaged on lifting;
- temporary fixity is provided when replacing fixed or guided bearings;
- jacking loads and movements are monitored for structural safety;
- voids are eliminated from bearing re-bedding and no excessive deflection is registered when jacking back down on the bedded bearing; and
- holding down bolts are greased and nuts locked tight by approved means.

When assessing the effects of jacking operations on the structure, the potential effects of a failure of a jack, or components, should be considered. Where multiple jacks are connected by a common component, e.g. a manifold or a hose, the failure of this component should also be considered. Designers should note that a failure can occur in jacking up or down operations. If jacking or monitoring is carried out remotely, consideration should be given to the time taken to address any failure. The principle of the assessment is to ensure that if a component fails, and the loads are redistributed, the effects of this have been taken into account and no damage or settlement will occur to the structure.

Where bearing replacement might be required during the life of a structure, the provision of a movement restraint (e.g. dowels) through the bearings can cause difficulties, and alternative location of the restraint(s) should be considered.

5.4 Effects of bearings on other parts of the structure

The design of other elements of the structure, including expansion joints, parapets and services, should take into consideration the effect of any change in the geometrical configuration of the bearings. (For replacement bearings, see also **4.4**.)

6 Manufacture

6.1 Materials

6.1.1 General

Where more than one quality of material is specified in the relevant British Standard or more than one British Standard is referred to in this document, the quality should be that specified or approved by the overseeing organization.

6.1.2 Dissimilar materials

Care should be taken to prevent electrolytic action between dissimilar metals in contact by the use of suitable insulation and the prevention of moisture penetration. (See also **10.7.1** and **10.7.3**.)

6.1.3 Protection of aluminium alloy components.

Where aluminium would otherwise be in contact with Portland cement concrete, the former should be suitably protected. (See also **10.7.3**.)

6.2 Surface finish on metal elements

Metal-to-metal contact surfaces within bearings should be prepared either by machining or fine grinding. As far as practicable, machining should be carried out after any welding has been finished. Machining of rolling contact surfaces of roller bearings or sliding contact surfaces should be carried out only in the principal direction of movement. Care should be taken to remove abrasive materials from finished surfaces, which should also be cleaned with a degreasing agent.

Finished surfaces should be protected from contamination and/or mechanical damage. Surfaces that are to be in contact with grout or bedded on a suitable material may be left unmachined.

The surface roughness R_a of metal sliding surfaces (guides) should not exceed 0.5 μm.

6.3 Sliding surfaces

6.3.1 Arrangement

Unless agreed with the overseeing organization, sliding bearings should have the larger of the sliding surfaces positioned above the smaller so that the sliding surfaces are kept clean.

6.3.1.1 Provision for rotation

Except as specified in BS EN 1337-2:2004, **6.4**, flat sliding surfaces should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding. Other provision should be made for rotation about an axis in the plane of sliding.

6.3.1.2 Thickness and attachment of austenitic steel sliding surfaces

Where BS EN 1337-2:2004, **7.2.1**, Table 13, only specifies a minimum thickness (⩾) of the austenitic steel sheet, the required thickness should be in accordance with Table 1 of this document provided that the Table 1 value is greater than the value specified in Table 13.

Table 1 **Thickness of austenitic steel sheet**

Dimensional difference between PTFE and austenitic steel mm	**Minimum thickness of austenitic steel** mm
⩽300	1.5
>300, ⩽500	2.0
>500, ⩽1 500	3.0

NOTE A dimensional difference in excess of 1 500 mm requires special consideration.

6.4 Elastomeric bearings

6.4.1 Basis of design

BS EN 1337-3:2005, **5.3.3**, requires that, where reinforcing plates are included in the bearing, they are chemically bonded to the elastomer, to prevent any relative movement at the steel/elastomer interface. They should be manufactured in accordance with **7.2.3**.

6.4.2 Shear resistance

An allowance of ±20% should be made in the calculated value of the nominal horizontal force due to expansion or contraction, to identify the most adverse effect to which the bearing is likely to be subjected.

Due allowance should be made in the value of the shear modulus of the elastomer for temperature variation. Consideration should be given to increasing the value of the shear modulus of the elastomer for movements due to live load effects on railway bridges. Specific values should be agreed with the overseeing organization, but it is suggested that the values are doubled.

6.4.3 Parallelism

The tolerance on parallelism for the axes of reinforcing plates with respect to the base of the bearing as datum should be 0.2% of the side length or 0.3% above 700 mm.

6.4.4 Plain pad and strip elastomeric bearings

The use of these bearings should be restricted to small and simply supported structures of spans less than 10 m.

6.5 Roller bearings and rocker bearings

6.5.1 Hardened steels in roller bearings and rocker bearings

Rollers and rockers should be through hardened and not case hardened.

The maximum difference in surface hardness of any single component should not exceed 30 HV and of any single bearing assembly should not exceed 50 HV.

6.5.2 Composite steels in roller bearings

Composite roller bearings should be of weldable structural steel with a minimum tensile strength of 470 N/mm^2. The contact surfaces of both the roller and roller plates should be faced with a hard corrosion-resistant surface, applied by weld deposition or forging, having a maximum hardness of 650 HV. The applied surface layer should consist of a tough buffer layer and a number of corrosion-resistant layers to give the required thickness.

The thickness in millimetres of the applied layer on the roller and plates, measured from the finished surface to the base metal, should be greater than:

$$0.14R - 2$$

where R is the minimum radius of the contact surface of the bearing in millimetres.

The chemical composition of the applied layers should be in accordance with Table 2.

6.5.3 Special steels in roller bearings

Special steels for use in the production of roller bearings where a permanent oil bath is provided should have a minimum tensile strength following hardening of 1 350 N/mm^2 and a maximum hardness of 530 HV. Prior to production, a detailed “sequence of hardening” procedure should be laid down and proof provided that this procedure does not give rise to significant metallurgical defects. Production of hardened roller bearings should follow this procedure in every respect.

The chemical composition of the steels should be as follows:

- C: 0.7% to 0.8%
- Si: 0.3% to 0.4%
- Mn: 0.8% to 0.9%
- Cr: 1.8% to 2.0%

Table 2 **Chemical composition of applied layers in roller bearings**

Composition of deposited layer %		**Composition of weld material for the buffer layer** %	
C	0.2–0.35	C max	0.1
Cr + Mo	12.0–18.0	Cr max	15.0
Mn	0.3–0.7	Mn	0.2–1.0
Si	0.2–0.6	Si	0.2–1.0
P max	0.03	P max	0.03
S max	0.025	S max	0.03
P max + S max	0.03	P max + S max	0.03
N max	0.02	N max	0.04

6.6 Knuckle and leaf bearings

NOTE Examples of different knuckle and leaf bearings are given in Figure 2.

6.6.1 General

6.6.1.1 Function

BS EN 1337 (all parts) does not cover cylindrical knuckle and leaf bearings, which are in use in the UK and provide for rotation. Leaf bearings can also be designed to resist uplift.

6.6.1.2 Curved surfaces

Any individual contact surface should have only one radius.

6.6.1.3 Mating surfaces

Mating surfaces should be turned and fitted.

6.6.1.4 Separation of parts

Horizontal forces applied to curved sliding surfaces tend to separate the contact surfaces of the bearing. Therefore, a check should be made to ensure that this tendency is adequately resisted by the concurrent vertical loads. The calculations for the destabilizing horizontal force and the restoring vertical force should be based on the requirements for preventing overturning.

6.6.1.5 Pins

Pins should be of sufficient length to ensure that all components connected thereby bear fully on them. Where the end of a pin is threaded, the threaded length of the pin should be turned to a smaller diameter and provided, where necessary, with a pilot nut to protect the thread.

6.6.1.6 Design limit state

Contact surfaces of knuckle and leaf bearings should be designed to meet the design requirements of this document at the SLS only.

6.6.1.7 Allowable bearing pressures

With metal-to-metal contact, the bearing pressure on the projected contact area (length of seating × diameter of pin) due to the design load effects should not exceed:

- one-half of the nominal yield stress of the weaker material or 120 N/mm^2, whichever is the lesser, for all grades of steel;
- 30 N/mm^2, for phosphor-bronze;
- 25 N/mm^2, for leaded bronze.

These limiting values allow for a partial safety factor of γ_m = 1.0 for the materials being used.

6.6.2 Pin and leaf knuckle bearings

For pins and seatings, the tolerance on cylindricity should be 0.025 mm.

For pins up to and including a diameter of 250 mm, the diameter:

- of the pins should be within a size tolerance of –0.25 mm to –0.40 mm;
- of the seating should be within a size tolerance of 0.0 mm to +0.15 mm.

For pins exceeding a diameter of 250 mm, the clearance between the pin and the seating should be not less than 0.4 mm and not more than 0.75 mm.

6.6.3 Cylindrical and spherical knuckle bearings

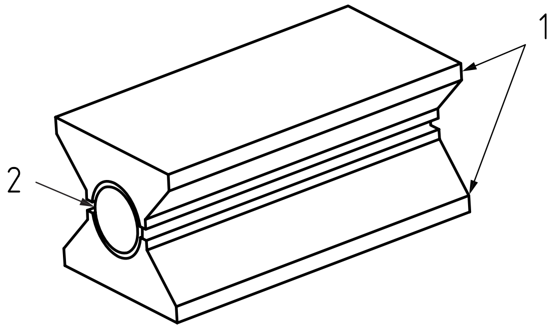
The tolerances on flatness and profile of surface for cylindrical knuckle bearings and tolerance on profile of surface for spherical knuckle bearings should be 0.000 3X mm or 0.2 mm, whichever is the greater, where X is the length of the chord (in mm) between the ends of the PTFE surface in the direction of rotation.

The size tolerance for the radius of the curved surface on the finished bearing should be 0.000 3X mm or 0.2 mm.

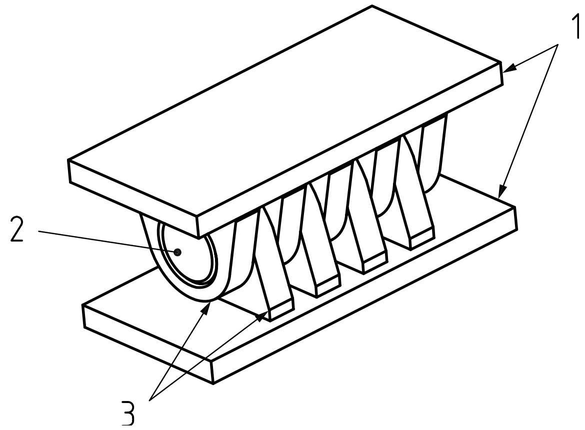
The surface roughness R_a of metal curved sliding surfaces should not exceed 0.5 µm.

Where PTFE forms one of the contact surfaces, it should conform to BS EN 1337-2.

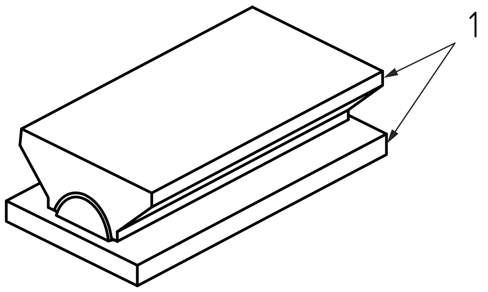
Figure 2 **Knuckle and leaf bearings**



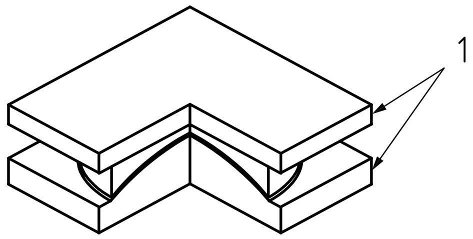
a) Knuckle pin bearing



b) Knuckle leaf bearing



c) Cylindrical knuckle bearing



d) Spherical knuckle bearing

Key

1 Outer bearing plates

2 Pin

3 Leaves

7 Connections

7.1 General

7.1.1 Bolts and bolt holes

Vibration-resistant fasteners should be specified where vibration is likely to be significant. Taper washers of the correct angle of taper to nullify the bevel should be provided under all heads and nuts bearing on bevelled surfaces.

7.1.2 Fixing holes in bearing plates

Where required, tolerances on the position for centres of fixing holes should conform to BS EN 1993-1-8, unless otherwise specified or approved by the overseeing organization.

7.1.3 Welding

7.1.3.1 General

Welding procedures should be such as to minimize distortion of the bearing components and to avoid damage to finished work or bonded materials.

7.1.3.2 Aluminium

Metal-arc and tungsten-arc welding of aluminium should conform to BS EN 1011-4.

7.1.3.3 Austenitic steel sheet

Welding of austenitic steel sheet to a mild steel backing plate should be by an inert gas-shielded metal-arc or tungsten inert gas metal-arc process. Electrodes used with the former method should be austenitic steel electrodes conforming to BS EN 1600.

The weld attaching the austenitic steel to its backing plate should be continuous so as to prevent ingress of moisture and should be clean, sound, smooth, uniform, without overlaps and properly fused.

7.1.4 Peripheral sealing of mechanically fixed austenitic steel sheet

Where the austenitic steel sheet is mechanically fixed in accordance with BS EN 1337-2:2004, **7.2.1**, a continuous flexible seal should be provided around the periphery of the stainless steel.

7.1.5 Bonding

7.1.5.1 Austenitic steel sheet

The austenitic steel sheet to be bonded should be prepared for bonding in accordance with BS EN 1337-2. It should be bonded over its entire area.

7.1.5.2 PTFE

The surface of PTFE to be bonded should be prepared for bonding in accordance with BS 5350-A1. When tested in accordance with BS EN 1464, the minimum bond strength between the PTFE and its backing plate should be 4 N per mm width.

7.2 Elastomeric bearings

7.2.1 Steel reinforcing plates

Internal steel laminates should be free from sharp edges. Methods used for forming holes or cutting plates should be such as to leave the material free from flaws, tears and rough edges.

7.2.2 Plain pad and strip bearings (Type F)

Plain pad bearings should be moulded in one piece, or comprise single pieces cut from previously moulded strips or slabs. Cutting should produce a smooth surface without injurious heating of the elastomer.

7.2.3 Laminated bearings

Laminated elastomeric bearings should be moulded as a single unit under pressure and heat.

7.2.4 Spacers in moulds

When spacers are used in moulds of elastomeric bearings to ensure correct cover to outer plates:

- the resulting exposed steel surfaces should eventually be covered when the bearings are installed in the bridge structure;
- the spacers should be located such that there is not less than 10 mm from the reinforcing plate edge to the edge of the spacer;
- the diameter of the hole left at the surface of the bearing should be not more than 10 mm;
- the minimum practical number of spacers should be used to ensure correct location of plates but in no case should the total area of spacers exceed 3% of the bearing compression area.

8 Final assembly, clamping and presetting

8.1 Final assembly and clamping of bearings

BS EN 1337-1:2000, **7.4.1**, specifies requirements for the temporary clamping of all bearings that are made up of several components and not rigidly fixed together, in preparation for handling, transportation and installation. Temporary clamping devices are specified for use in maintaining the correct orientation of the parts. It is important to ensure that the clamping devices are not used for slinging or suspending bearings for supporting construction loads or forces, unless specifically designed for this purpose.

Assembly and clamping should take place after final inspection and acceptance of the various parts of the finished bearing. If specified by the overseeing organization, sliding and roller bearings should be preset at the time of fixing the clamping devices. All deleterious materials should be excluded from sliding and other contact surfaces.

8.2 Presetting of bearings

BS EN 1337-1:2000, Clause **4**, requires that the presetting of bearings is avoided wherever possible, but, if necessary, that it is undertaken at the manufacturer's factory and any on-site readjustment is carried out either by the manufacturer or under his supervision. If bearings are preset at the manufacturer's works, the amount of preset is very difficult to determine owing to the uncertainty of the amount of creep and shrinkage that takes place and the temperature at the time of installing the bearing. If bearings are to be preset on site, the manufacturer should be so notified at the time of ordering so that due provision can be made for the movement of the relevant parts.

NOTE BS EN 1337-11:1997, Annex A, gives guidance on estimating the temperature of the structure at the time of installation.

9 Testing

NOTE The following guidance on testing applies when specified by the customer.

9.1 Acceptance tests

BS EN 1337 (all parts) uses the concept of type approval tests and then relies on conformity evaluation to ensure compliance. However, it is the prerogative of customers to specify other tests. This subclause is intended to provide guidance on the conduct of those tests, should they be specified.

The requirement for, and the extent of, testing of completed bearings depends upon the evidence of previous tests and the level of quality control on the bearings and their parts (materials and workmanship). The properties and performance of proprietary and special types of bearings should be confirmed by tests or by properly documented evidence.

Acceptance tests, to confirm that the complete bearing conforms to the performance requirements given in the contract, should be carried out as specified by the overseeing organization. When available, the results of type and production tests should be taken into account in specifying the acceptance tests.

In deciding on the need for and the type and scope of the acceptance tests, the following factors are relevant.

a) The existence of previous well-attested and documented information, giving a full description of the bearings tested, their material properties, and all other data that might affect the performance of the bearing.

b) Service conditions of the bearings.

   Careful consideration should be given to conditions likely to affect the bearing in service and reduce its efficiency. These should, where practicable, be simulated in the tests. Examples of possible causes of adverse effects are: extremes of temperature, variations in rate of loading compared to that used in the tests, exposure of rubber to sunlight, and deterioration of lubricants used to reduce the coefficient of friction in sliding bearings.

c) The importance of the bearing in relation to the structure.

d) The complexity of the bearing design.

e) The extent of testing and inspection of materials and workmanship during fabrication.

f) The extent to which previous tests are representative of the routine fabrication procedure.

g) The access for inspection and ease of replacement of the bearing after installation.

h) The type of testing required.

   The choice of the type of test or combination of tests is determined by the objectives, since each of the tests has a different purpose. In the case of bearings where performance cannot be fully evaluated prior to manufacture, the need for well-attested data and testing to validate their design is usually essential.

i) The number of bearings of any one type to be tested.

Additional bearings should be allowed for where any testing under ULS loads is called for. Sampling of bearings for the test should be as representative as possible.

j) The availability of facilities for testing.

In deciding on the nature and extent of testing, due regard should be paid to the availability of equipment of adequate capacity to apply the loads, movements and rotations specified in the test. Where such equipment is not readily available, proof loading might be impracticable and tests on reduced-size bearings might have to be adopted to provide evidence of the performance of full-size bearings. If scale factors apply, restrictions might have to be imposed on the use of results of the testing.

9.2 Load testing

9.2.1 Bearings (other than elastomeric)

Load tests are needed to check the performance of the bearing at both the SLS and ULS. The purpose of these tests is to verify the performance of a bearing for which no relevant test data are available. The verification should be at the SLS or ULS, or both, as appropriate, and as specified by the overseeing organization. A test is not necessarily needed as, in many cases, static calculations are adequate verification.

Both vertical and horizontal loads, where applicable, should be applied to the bearing in the most adverse combinations as specified in BS EN 1990:2002+A1, **A.2**, and as specified by the overseeing organization.

Load transfer in the testing device owing to tilting of the bearing should be taken into account, where applicable.

Before recording measurements, the bearing should be bedded in by applying a load equal to the SLS load and then releasing it. The test loads should then be applied in increments and load deflection measurements made at each increment. The rate of loading should be slow enough to avoid any adverse shock effects and the maximum load should be maintained until any obvious short-term creep has ceased.

The load should then be removed in decrements and load deflection measurements made at each decrement. For SLS load tests, after complete unloading, the amount of set should be checked and, if significant, the loading and unloading cycle repeated. If the set is shown to be progressive, the bearing should be deemed not to conform to the relevant part of BS EN 1337 and should not be accepted.

After being tested, a bearing should be dismantled as necessary for inspection. Where a bearing is to be test loaded to both limit states, it should be tested for serviceability first and then dismantled as necessary and inspected before being tested for the ULS. In such cases it should have a second bedding-in cycle before the second load test.

Load tests at the SLS should be carried out using the characteristic values of load effect as specified in the bearing schedule. A bearing should be considered to have passed an SLS test provided that there is no visible damage or permanent deformation of any part due to loading cycles subsequent to the initial bedding-in cycle.

Load tests at the ULS should be carried out using the ULS design load effects, as specified in the bearing schedule, multiplied by:

- 1.1 for all materials other than aluminium alloy castings;
- 1.3 for aluminium alloy castings.

These factors correspond to the values of γ_M used in the bearing design.

A bearing may be considered to have passed this test if it supports the test load. However, due regard should be paid to the results of the tests to establish the strength of materials used in the fabrication of the bearing. Where the material strength is significantly above the minimum specified, the possibility of weaker materials being used in other bearings should be taken into account when assessing the strength of such bearings.

Bearings tested for the SLS should be suitable for subsequent incorporation in the structure provided they have been both reassembled and warranted by the manufacturer, but bearings tested for the ULS should not be incorporated in the structure.

9.2.2 Elastomeric bearings

9.2.2.1 General

Testing on elastomeric bearings should be in accordance with BS EN 1337-3. Additional guidance is given in **9.2.2.2** and **9.2.2.3**.

9.2.2.2 Quick compressive test

A quick compressive test for elastomeric bearings is specified in BS EN 1337-3:2005, **4.3.3.3** and Annex H. This test is normally made on all bearings by the manufacturer to check for misplaced reinforcing plates, bond failures at the steel/elastomer interface, surface defects and stiffness.

BS EN 1337-3:2005, **4.3.3.2**, requires that the deflection between one-third and full test load is recorded and used to check the consistency of the stiffness values. The result for stiffness obtained for any particular bearing should be repeatable to within 5%.

Where test results on a series of bearings are being compared, the same method should be used throughout. All these tests should be carried out on the same testing machine. The tests on a batch of bearings should be completed within a period of 24 hours, wherever possible, and in no case exceeding 72 hours. Where, on a batch of the same bearings, the vertical stiffness value of an individual bearing varies by more than 20% from the average value from the batch, the bearing should not be accepted.

If the manufacturer performs this test and makes the results available, further tests for acceptance of bearings should not be necessary.

9.2.2.3 Stiffness test

The test method specified in BS EN 1337-3:2005, Annex H, covers stiffness testing for elastomeric bearings. This test is particularly important in cases where the compressive stiffness of the bearing is critical to the design of the structure as the quick compressive test is likely to overestimate the stiffness.

The range of compressive stiffness used in the design of the structure should be as large as possible to give the bearing designer maximum flexibility.

9.2.3 Testing resistance to movement

9.2.3.1 Frictional resistance

Bearings conforming to BS EN 1337, as relevant, need not be tested for resistance to movement, unless the supplier claims a substantial improvement in this respect. The design coefficients of friction are intended to represent the worst values likely to develop during the life of the bearing and can only be verified by tests simulating the conditions that might be expected to arise during the design life of the bearing.

Short-term tests are not suitable for determining coefficients of friction for design purposes, as such tests give much lower coefficients than recommended for design. The extent of this reduction depends on the type of bearing and the nature of the contact surfaces, especially if lubricants are used. The test procedures given in BS EN 1337-2 are not intended to be used for research purposes: they are quality assurance tests.

9.2.3.2 Elastomeric resistance

Where well-attested test results are available for both compression and shear stiffness tests and where the compression stiffness test result for a bearing is within 20% of the average of the previous results, the shear stiffness of the bearing may be assumed to be within 20% of the average of the corresponding shear stiffness results.

Where such results are not available, or where the overseeing organization requires additional confirmation, a shear stiffness test may be performed.

9.3 Testing of complete bearings

9.3.1 General

When specified by the overseeing organization, additional testing may be carried out in accordance with **9.1** and **9.2**. The bearings should be considered satisfactory when the results of the tests follow the recommendations of this document and conform to the relevant part of BS EN 1337 and any special requirements specified by the overseeing organization.

9.3.2 Number of tests

The required number of each type of test should be inserted in the bearing schedule. Unless otherwise required by a special feature of the design, the number and type of acceptance tests should be as follows.

a) Bearings (other than elastomeric).

   One complete bearing of each type should be subjected to a vertical load test or, if the bearing is also to resist horizontal load, a combined vertical and horizontal load test at the SLS. A load test to the ULS is only necessary when the design of the bearing or any of its components, made from materials other than structural steel, is governed by an ultimate criterion; design of structural steel components of a bearing need not be verified by load tests at the ULS. Well-attested and documented evidence of previous, independently supervised tests on similar bearings may be accepted as an alternative to the specified tests.

b) Laminated elastomeric bearings.

A quick production test should be carried out for each bearing. One in every 20 bearings of the same type should be subjected to shear stiffness tests. In addition, where the vertical deflection of the bearing under load is critical to the design of the structure, compressive stiffness tests should be carried out on one in every 20 bearings of the same type.

9.4 Elastomer

In the test to determine the shear stiffness, instability becomes apparent from the load/deflection graph. Slip or bond failure might show as excessive set or a marked reduction in the slope of the load/deflection curve.

Where the shear modulus inferred from the results varies considerably from that assumed in the design of the bearing, further testing should be considered, e.g. tests to determine the tensile strength and elongation at break and high temperature compression set of the elastomer from samples cut from the bearing.

Test samples, which need to be taken from near the centre of a laminated bearing, may be taken from a finished bearing provided that it has been manufactured with steel reinforcing plates that have holes of a suitable size and location to allow cored samples. Finished bearings that have had test samples removed may be used provided that, after repair, they pass the compression test.

9.5 Other materials

When assessing the suitability of materials other than those given in this document or the relevant part of BS EN 1337 for use in structural bearings, the following factors should be taken into consideration.

a) Physical and mechanical properties:

- ultimate compressive strength;
- ultimate tensile strength;
- ultimate shear strength;
- proof strength;
- impact strength;
- resistance to sustained and repeated loading;
- stress/strain curves;
- elastic modulus;
- bulk modulus;
- creep, ductility and pliability;

- coefficient of friction (static and dynamic);
- effect of high and low temperatures on the above properties.

b) Durability:

- attack by water, alkalis, acids, bacteria, oxygen, ozone, chlorides, sulfates, hydrocarbons, and other chemicals commonly transported by road;
- effect of ultraviolet and infra-red rays, fire, heat and cold;
- electrolytic action between materials likely to be in contact with each other.

9.6 Test certificates

Test certificates for materials and workmanship should be made available for inspection, when required, in accordance with BS EN 10204:2004, level 3.1, as a minimum.

10 Installation

10.1 General

Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. In order that moving surfaces are not contaminated, pre-assembled bearings should not be dismantled after leaving the manufacturer's works except under expert supervision and with the manufacturer's assistance.

Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding to resist the applied load. Temporary clamping devices should be removed before the bearings are expected to accommodate movement. Consideration should be given to any treatment needed for holes exposed on the removal of temporary transit clamps. Where reuse of these fixing holes might be necessary, the material selected to fill them should not only give protection against deterioration but should also be easily removable without damaging any threads.

Where necessary, suitable arrangements should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure. When provided, temporary supports under bearing base plates should be compressible under design loading if not removed once the bedding material has reached the required strength. Any voids left as a consequence of their removal should be made good using the same type of bedding material. Steel folding wedges and rubber pads are suitable for temporary supports under bearing base plates.

Any temporary packing between the outer bearing plates and the structure should be positioned such that it is not detrimental to the bearing or the structure. After installation, bearings and their surrounding areas should be left clean.

The installation tolerances may be relaxed provided that the relaxed tolerances are allowable within the design. Twin and multiple bearings are normally used on box girders; the tolerances for departures from common planarity should be determined from the capacity of the box girders to resist torsion caused by this imperfection.

10.2 Setting of bearings

Unless otherwise specified or agreed by the overseeing organization:

- bearings should be located so that their centre lines are ±3 mm from their correct position.
- the level of a single bearing or the mean levels of more than one bearing at any support should be within a tolerance of ±0.000 1 times the sum of the adjacent spans of a continuous girder but not exceeding ±5 mm.

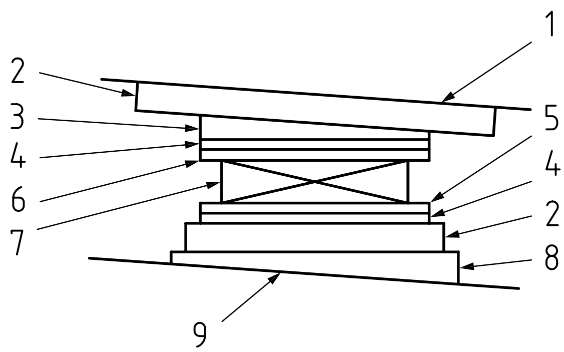
Departures from common planarity of twin or multiple bearings should be within such tolerances as specified by the overseeing organization.

10.3 Tolerances for spreader, spacer and taper plates

Surfaces of spreader, spacer and taper plates should be treated in such a way that after painting the maximum deviation ΔZ from the theoretical plane does not exceed 0.000 3 × d or 0.2 mm, whichever is the greater, where d is the diagonal or diameter of the plate.

This tolerance covers both local and gradual deviations in the metal from the designed plane surfaces and includes any variations in paint thickness. Thinner plates should be avoided, where possible. (See Figure 3.)

Figure 3 **Typical bearing detail**



Key

1 Bridge deck
2 Spreader plate
3 Taper plate
4 Spacer plate
5 Bottom plate
6 Top plate
7 Moving part
8 Bedding mortar
9 Pier, bankseat or abutment

10.4 Threaded fixings

Threaded fixings should be tightened uniformly to avoid overstressing any part of the bearing. Where specified or required by the overseeing organization, fasteners should be of a vibration-resistant type.

10.5 Bedding

The choice of bedding material is influenced by the method of installing the bearings, the size of the gap to be filled, the strength required and the setting time. When selecting the bedding material, consideration should therefore be given to the following factors:

- type and size of bearing;
- loading on bearing;
- construction sequence and timing;
- early loading;
- friction;
- dowelling arrangements;
- access around the bearing;
- design and condition of surfaces in the bearing area;
- required thickness of the bedding material;
- shrinkage of the bedding material.

Bedding mortars should be approved by the overseeing organization.

The composition and workability of the bedding material should be specified with these factors in mind. In some cases it might be necessary to carry out trials to ascertain the most suitable material. Commonly used materials are cementitious or chemical resin mortar, grout and dry packing. The use of materials such as lead, which tend to flow under load, leaving hard spots, should be avoided.

Bearings should be bedded over their whole area. After installation there should be no voids or hard spots. The bedding material should be capable of transmitting the applied load to the structure without damage.

The top surface of any extension of the bedding beyond the bearing should have a slope away from the bearing.

10.6 Steel

Precautions should be taken to prevent staining of the supporting structure.

10.7 Protective measures

10.7.1 General

Shop-applied treatment should not be returned on to faces not permanently exposed. Stripe coats should be applied to plate edges and stepped surfaces after installation and application of dead load.

Due to the risk of electrolytic action, it is important to prevent the contact of dissimilar materials. In this context, mild steel and stainless steel are dissimilar. In particular, direct contact between copper, nickel and their alloys (e.g. brass and bronzes) with aluminium, and aluminium with steel should be avoided. Copper can be affected by direct contact with concrete.

*NOTE For further information, refer to PD 6484. See also **6.1.3**.*

10.7.2 Protection colour

The colour of the top protection coat should match the colour of any adjacent steelwork and should be approved by the overseeing organization.

10.7.3 Protection of aluminium alloy components

The surfaces and adjacent edges of aluminium alloy components, which will be in contact with concrete or mortar, should be treated before installation with two coats of alkali-resistant bituminous paint conforming to BS 3416 or BS 6949.

10.7.4 Fixing of bearings

10.7.4.1 Bearings other than elastomeric

To cater for vibration and accidental impact, some fixing should be provided. Shear keys or holding-down bolts should be set into recesses cast into the structure using templates. The remaining voids in the recesses should be filled with a material capable of withstanding the loads involved. Close tolerance bolts should be set using the bearings as templates. In this case, special precautions should be taken to prevent contamination of the bearings during bolt installation.

Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by the holding-down bolts or other means to prevent disturbance during subsequent operations. The method of bolt tightening should be such as not to deform the bearings. Finally, voids beneath the bearings should be completely filled with bedding material using the appropriate method.

Hard spots should be avoided, e.g. by removal of temporary packing shims and the use of resilient washers under backnuts. Alternatively, bearings may be fixed directly to metal bedding plates that are cast in or bedded on top of the supporting structure to the correct level and location. Only a thin layer of bedding mortar should be used and this mortar, when other than synthetic resin mortar, should be housed in a recess suitably reinforced on all sides.

If the substructure is of steel, the bearings may be bolted directly to it. In such cases, there might be difficulties in achieving location to line and level within the tolerances unless other provision is made. Before providing for adjustment, the need for such accurate location should be assessed.

10.7.4.2 Bearings supporting in-situ concrete deck

Where bearings are installed prior to forming an in-situ concrete deck, formwork around the bearings should be carefully sealed to prevent grout leakage. However, it is essential that the bearings and particularly the working surfaces are protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete. Any mortar contaminating the bearings should be completely removed before it sets.

10.7.4.3 Bearings supporting precast concrete or steel elements

A thin layer of synthetic resin mortar should be used between bearings and precast concrete beams. Alternatively, bearings with outer bearing plates may be bolted to anchor plates or sockets embedded in precast elements, or to machined sole plates on steel elements.

11 Guidance on specification requirements

Where proprietary bearings are to be used, the contractor should design the bearings. A bearing schedule should be provided and a statement included thereon that "The bearings should be designed in accordance with BS EN 1337 supplemented as appropriate by this document".

Annex A (normative) Bearing schedule

The bearing design requirements and acceptance tests should be listed in a bearing schedule. A typical bearing schedule is given in BS EN 1337-1:2000, Table B.1, which has been extended in this document to cover UK practice (see Table A.1).

Table A.1 **Typical bearing schedule**

1	Structure name or reference							
2	Bearing identification mark							
	Type of bearing (number in accordance with BS EN 1337-1, Table 1)							
3	Quantity							
4	Seating	Material[1]		Upper surface				
5				Lower surface				
6		Characteristic strength (N/mm^2)		Upper surface				
7				Lower surface				
8	Support area	Upper surface		Longitudinal (mm)				
9				Transverse (mm)				
10		Lower surface		Longitudinal (mm)				
11				Transverse (mm)				
12	Actions (kN)	Characteristic maxima (SLS)	Vertical $N_{Ed,ser}$	max.				
13				permanent				
14				min.				
15			Transverse $V_{y_{Ed,ser}}$					
16			Longitudinal $V_{x_{Ed,ser}}$					
17		Design maxima	Vertical N_{Ed}					
18			Transverse $V_{y,_{Ed}}$	Permanent				
19				T, S, C[2]				
20				Variable				
21			Longitudinal $V_{x,_{Ed}}$	Permanent				
22				T, S, C[2]				
23				Variable				
24		Characteristic Combination (SLS)	max. $N_{Ed,ser}$					
25			max. $V_{Ed,ser}$					
26		Characteristic Combination (SLS)	min. $N_{Ed,ser}$					
27			max. $V_{Ed,ser}$					
28		Design Combination	max. N_{Ed}					
29			max. V_{Ed}					
30		Design Combination	min. N_{Ed}					
31			max. V_{Ed}					
32	Displacement (mm)	Characteristic (SLS)	Irreversible	Transverse $v_{y,Ed,ser,i}$				
33				Longitudinal $v_{x,Ed,ser,i}$				
34			Reversible	Transverse $v_{y,Ed,ser,r}$				
35				Longitudinal $v_{x,Ed,ser,r}$				
36		Design	Irreversible	Transverse $v_{y,Ed,i}$				
37				Longitudinal $v_{x,Ed,i}$				
38			Reversible	Transverse $v_{y,Ed,r}$				
39				Longitudinal $v_{x,Ed,r}$				

Table A.1 **Typical bearing schedule** *(continued)*

40	Rotation (radians)	Characteristic (SLS)	Irreversible	Transverse $\alpha_{y,Ed,ser,i}$				
41				Longitudinal $\alpha_{x,Ed,ser,i}$				
42			Reversible	Transverse $\alpha_{y,Ed,ser,r}$				
43				Longitudinal $\alpha_{x,Ed,ser,r}$				
44		Design	Irreversible	Transverse $\alpha_{y,Ed,i}$				
45				Longitudinal $\alpha_{x,Ed,i}$				
46			Reversible	Transverse $\alpha_{y,Ed,r}$				
47				Longitudinal $\alpha_{x,Ed,r}$				
48		Maximum rate (100 × radians / kN)		Transverse $\alpha_{y,Ed,ser,max}$				
49				Longitudinal $\alpha_{x,Ed,ser,max}$				
50	Maximum bearing dimensions (mm)	Upper surface		Transverse				
51				Longitudinal				
52		Lower surface		Transverse				
53				Longitudinal				
54		Overall height						
55	Tolerable movement of bearing under transient loads (mm)			Vertical				
56				Transverse				
57				Longitudinal				
58	Maximum acceptable reaction to displacement under serviceability limit state (kN)			Transverse $W_{y,ser}$				
59				Longitudinal $W_{x,ser}$				
60	Maximum acceptable reaction to rotation under serviceability limit state (kNm)			Transverse $M_{y,ser}$				
61				Longitudinal $M_{x,ser}$				
62	Type of fixing required			Upper face				
63				Lower face				
64	Special requirements			State any other requirements on separate sheet.				
	Acceptance testing							
	Number of complete bearings to be subjected to acceptance testing	Bearing type	Test	Test factor				
65		Bearings other than elastomeric	Vertical test and combined vertical and horizontal characteristic load test (all materials) [3]	1				
66			Vertical test and combined vertical and horizontal design load test – steel bearings (including pot bearings) [3]	1.1				
67			Combined vertical and horizontal design load – aluminum alloy bearings [3]	1.3				
68		Laminated elastomeric bearings	Quick production test	1				
69			Compression stiffness test	1				
70			Shear stiffness test	1				

[1] For example cement mortar, epoxy mortar, in-situ concrete, precast concrete, steel, timber.

[2] Temperature, shrinkage and creep.

[3] Test load should be derived from the product of the design load and the test factor above.

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