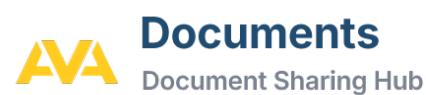




Bridge design

Part 4: Bearings and deck joints



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 - Australian Steel Institute
 - Austroads
 - Bureau of Steel Manufacturers of Australia
 - Cement and Concrete Association of New Zealand
 - Cement Concrete & Aggregates Australia—Cement
 - Concrete Institute of Australia
 - Consult Australia
 - Engineers Australia
 - New Zealand Heavy Engineering Research Association
 - Rail Industry Safety and Standards Board
 - Steel Construction New Zealand
 - Steel Reinforcement Institute of Australia
 - Sydney Trains
-

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Australian Standard[®]

Bridge design

Part 4: Bearings and deck joints

Originated as HB 77.4—1996.
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PREFACE

This Standard was prepared by the Standards Australia Committee BD-090, Bridge Design to supersede AS 5100.4—2004.

This Standard is also designated as Austroads publication AP-G51.4-17.

The objectives of the AS(AS/NZS) 5100 series are to provide nationally acceptable requirements for—

- (a) the design of road, rail, pedestrian and cyclist-path bridges;
- (b) the specific application of concrete, steel and composite steel/concrete construction, which embody principles that may be applied to other materials in association with relevant Standards; and
- (c) the assessment of the load capacity of existing bridges.

The objective of this Part (AS 5100.4) is to specify requirements for the design and selection of bearings and deck joints for bridges in Australia.

The requirements of the AS(AS/NZS) 5100 series are based on the principles of structural mechanics and knowledge of material properties, for both the conceptual and detailed design, to achieve acceptable probabilities that the bridge or associated structure being designed will not become unfit for use during its design life.

Whereas earlier editions of the Bridge design series were essentially administered by the infrastructure owners and applied to their own inventory, an increasing number of bridges are being built under the design-construct-operate principle and being handed over to the relevant statutory authority after several years of operation. This Standard includes clauses intended to facilitate the specification to the designer of the functional requirements of the owner, to ensure the long-term performance and serviceability of the bridge and associated structure.

Significant differences between this Standard and AS 5100.4—2004 are the following:

- (i) Tables of standard elastomeric bearing properties have all been updated to add additional numbers of elastomer layers in each plan size.
- (ii) The requirements for the sealing rings of pot bearing have been modified.
- (iii) Spherical advanced composite material bearings have been introduced.
- (iv) The movement range deck joints need to be designed for have been modified.
- (v) Load distribution from bearings to concrete surfaces has been introduced.
- (vi) Project-specific requirements (Appendix E) have been added.
- (vii) Provisions for modular bridge expansion joints (MBEJ) have been added.

In line with Standards Australia policy, the words ‘shall’ and ‘may’ are used consistently throughout this Standard to indicate, respectively, a mandatory provision and an acceptable or permissible alternative.

Statements expressed in mandatory terms in Notes to Tables are deemed to be requirements of this Standard.

The term ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of the Standard. An ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard
Bridge design

Part 4: Bearings and deck joints

1 SCOPE

This Standard sets out minimum design and performance requirements for bearings and deck joints for the articulation and accommodation of movements of bridge structures. It applies to elastomeric, pot, spherical and mechanical bearings and deck joints, all of which are locations where rotation or translation, or both, can take place. It does not apply to concrete hinges.

2 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard.

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

1683	Methods of test for elastomers
1683.11	Method 11: Tension testing of vulcanized or thermoplastic rubber
1683.12	Method 12: Rubber, vulcanized or thermoplastic—Determination of tear strength (trouser, angle and crescent test pieces)
1683.14.1	Method 14.1: Adhesive strength of vulcanized or thermoplastic rubber—One-plate method
1683.15.1	Method 15.1: International rubber hardness
1683.15.2	Method 15.2: Durometer hardness
1683.22	Method 22: Determination of vulcanization characteristics using the oscillating disc curemeter
1683.24	Method 24: Determination of the resistance of vulcanized or thermoplastic rubbers to ozone cracking—Static strain test
1683.26	Method 26: Rubber, vulcanized or thermoplastic—Accelerated ageing or heat-resistance tests
5100	Bridge design
5100.2	Part 2: Design loads
5100.5	Part 5: Concrete

AZ/NZS

1554	Structural steel welding
1554.5	Part 5: Welding of steel structures subject to high levels of fatigue loading
2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
5100	Bridge design
5100.6	Part 6: Steel and composite construction

ISO

815	Rubber, vulcanized or thermoplastic—Determination of compression set
815-1	Part 1: At ambient or elevated temperatures
13000	Plastics—Polytetrafluoroethylene (PTFE) semi-finished products
13000-1	Part 1: Requirements and designation

EN

1337 Structural Bearings
1337-5 Part 5: Pot bearings

ASTM

A240/A240M-03b Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications

C719-14 Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)1, 2

5973 Standard Specification for Elastomeric Strip Seals with Steel Locking Edge Rails Used in Expansion Joint Sealing

NCHRP

Report 467 Performance Testing for Modular Bridge Joint Systems

3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

3.1 Bonded layer

A layer of elastomer bonded on both faces to metal plates, achieved by a vulcanization process.

3.2 Deck joint

A structural discontinuity between two elements, at least one of which is a deck element, which is designed to permit relative translation or rotation, or both, of abutting structural elements.

3.3 Laminated bearing

An elastomeric bearing with two or more metal plates bonded into the elastomer.

3.4 Modular deck joint

A joint that consists of a number of transverse beams and seals that are connected to a series of support mechanisms that provide a large movement capability.

3.5 Plain bearing

A bearing made up of a single unbonded layer of elastomer.

3.6 Pot bearing

A bearing that carries vertical load by compression of an elastomeric disc confined in a steel cylinder and which accommodates rotation by angular deformation of the disc.

3.7 Rated load

The calculated maximum permissible compressive load that is applied to a bearing when it is subjected at the same time to specified shear strain and rotation.

3.8 Semi-bonded layer

A layer of elastomer bonded on one face to a metal plate.

3.9 Spherical bearing

Bearing consisting of a plate with a convex spherical surface and a plate with a concave spherical surface between which a low friction sheet and a mating material form a curved sliding surface.

3.10 Strip bearing

A plain bearing pad in which the length is more than 10 times the width.

3.11 Unbonded layer

A single layer of elastomer that is not bonded to metal plates.

4 NOTATION AND ABBREVIATIONS

4.1 Notation

The symbols used in this Standard are as listed below.

Unless a contrary intention is given, the following applies:

- (a) Where non-dimensional ratios are involved, both the numerator and denominator are expressed in identical units.
- (b) The dimensional units for length and stress in all expressions or equations are to be taken as millimetres (mm), Newtons (N) and megapascals (MPa) respectively, unless specifically noted otherwise.
- (c) An asterisk (*) placed after a symbol as a superscript denotes a design action effect due to the design load for the ultimate limit state (ULS).

Symbol	Definition
A_b	bonded surface area
A_{cs}	reduced contact area of the curved sliding surface
A_{eff}	effective loaded plan area, nominally equal to the projected area common to top and bottom when a bearing is distorted tangentially
A_p	projected contact area (length of the seating times the diameter of the pin)
A_r	total rubber plan area
A_1	effective loaded area at the interface of the attachment plate and the mortar pad or concrete substrate
A_2	maximum distribution area based on a dispersion angle from the effective loaded area through the mortar pad and concrete
a	plan dimension of the edge of the bonded surface of rectangular bearings parallel to the span of the bridge
B	bulk modulus of elastomer
B_c	width of centre beam at top
B_w	contact width of dual truck tyres
b	plan dimension of the edge of the bonded surface of a rectangular bearing transverse to the span of the bridge
b_e	lesser of a and b for rectangular bearings
b_1	load distribution width at the interface of the attachment plate and motor pad
b_2	load distribution width based on the dispersion angle through the motor pad and concrete
C_1, C_2	constant dependent on bearing shape
D_L	design life of the component, in years
d	plan diameter of circular bearing at edge of bonded surface

d_c	total compressive deflection
d_1	diameter of the elastomeric pad within the pot bearing
d_2	diameter of the projected plan area of the approved sliding material (ASM) sliding surface
E_c	effective compression modulus of elastomer
E_h	homogeneous compression modulus
E_r	effective rotation modulus of elastomer
E_s	Young's modulus of elasticity
e	eccentricity
f'_c	lesser of the 28 days compressive cylinder strength of the mortar or concrete substrate
f_d	design compressive strength of approved sliding material (ASM)
f_n	normal stress
f_o	stress used in calculation of anchorage of laminated bearing
f_p	principal stress
f_r	resultant stress
f_{rn}	fatigue detail category defined in AS/NZS 5100.6, which is the corrected fatigue strength (in MPa) at 2×10^6 cycles
f_u	tensile strength used in design
f_y	nominal yield strength of metal plates; <i>or</i> nominal yield stress used in design
f_s	detail category fatigue strength at cut-off limit
G	chord shear modulus
g_c	gap between centre beams at appropriate joint opening
H	horizontal force; <i>or</i> shear force, serviceability limit state (SLS)
H^*	horizontal force; <i>or</i> shear force, ultimate limit state (ULS); <i>or</i> design longitudinal force
h	minimum protrusion of sliding material above the recess in curved backing plate of a spherical bearing
I	second moment of area of the plan area of the elastomer about its axis of rotation
J_u	maximum ultimate opening between edge beams of a modular deck joint
K_c	compressive stiffness of a bearing
K_{cn}	compressive stiffness of an individual layer n of elastomer in a laminated bearing
K_h	lateral horizontal stiffness
K_r	rotational stiffness of bearing
K_{rn}	rotational stiffness of a layer n
K_s	shear stiffness of an elastomeric bearing

K_v	effective compression stiffness
L	diameter of the projected area of the sliding material; <i>or</i> length of the cylinder
L_w	tyre contact length in direction parallel to traffic
M	rotational moment
m	ratio of the sides of a rectangular laminated bearing
N	compressive load on a bearing, serviceability limit state (SLS); <i>or</i> design bearing load
N_c	number of centre beams supported on a support bar
$N_{\min.}$	minimum permanent compressive load normal to the bearing anchorage interface concurrent with H , serviceability limit state (SLS)
$N_{\min.PE}$	minimum compressive load, due to permanent load effects, normal to the bearing anchorage interface concurrent with H
N^*	design axial force at ultimate limit state (ULS)
$N^*_{\min.}$	minimum concurrent load acting in compression normal to the bearing anchorage interface, ultimate limit state (ULS)
n_a	number of bearings contributing to adverse frictional load
n_e	number of effective cycles of vibration following excitation
n_r	number of bearings contributing to relieving frictional load
n_{sc}	design number of stress cycles caused by the design load
P^*	vertical load
P	surface perimeter for laminated elastomeric bearings
p	tyre inflation pressure
Q^*	vertical design force
Q^*_{up}	upward rebound force on the yoke of a modular deck expansion joint due to the passage of a wheel load across the joint
q	ratio
R	support reaction
R^*	fatigue resistance for the appropriate detail category
R_{lim}	ultimate section or member capacity of a component of a modular deck joint
R_{ua}	characteristic ultimate shear capacity of mechanical anchors
r	radius of cylindrical roller or rocker; <i>or</i> radius of spherical rocker
r_1	radius of the concave seating
S	shape factor of a layer of elastomer; <i>or</i> shape factor of the thickest inner layer
S^*	design action effect (force, stress, stress range, etc) for the appropriate limit state; <i>or</i> design action in general
s	shear stress
T^*	transverse design force

t	total thickness of elastomer in a laminated bearing or thickness of plain pad or strip bearing; <i>or</i> thickness of the overlying concrete and permanent surfacing layer
t_c	thickness of a cover layer of a laminated elastomeric bearing
t_e	effective thickness of an individual elastomer layer in compression (due to vertical load or rotation)
t_i	thickness of an individual inner layer of elastomer in a laminated bearing
t_n	thickness of a typical layer n of elastomer
t_p	thickness of the plate
t_s	thickness of metal plates
W	wheel load
w	width of strip
α	maximum angle of rotation, that is, change in angle between top and bottom surfaces of bearing in critical direction; <i>or</i> dynamic load allowance
α_a	angle of rotation parallel to the span of the bridge
α_b	angle of rotation transverse to the span of the bridge
β	distribution factor
β_a, β_r	factors dependent on the numbers of bearings n_a and n_r
χ	dynamic amplification factor (DAF)
χ_{dn}	downward component
χ_{mod}	overall dynamic amplification factor
χ_{LB}	lower bound value of the dynamic amplification factor
χ_{UB}	upper bound value of the dynamic amplification factor
χ_{up}	upward component
δ_a	maximum shear displacement tangential to bearing surface in the direction of dimension a due to movements of the structure and tangential forces
δ_b	maximum shear displacement tangential to bearing surface in the direction of dimension b due to movements of the structure and tangential forces
δ_s	maximum resultant vector shear displacement tangential to the bearing surface, considering movements of the structure and imposed shear force
η	ratio of the longitudinal force in the direction of traffic to the concurrent vertical load
τ	ratio of the force perpendicular to the direction of traffic to the concurrent vertical load
ϕ	capacity reduction factor
ϕ_f	capacity reduction factor for friction
ϕR_{ua}	design capacity of mechanical anchors
ε_c	compressive strain due to loads normal to the bearing surfaces
ε_{sc}	shear strain at edge of bonded surface due to loads normal to bearing surfaces

ε_{sh}	shear strain at edge of bonded surface due to forces tangential to the bearing surface or movement of the structure, or both
ε_{sr}	shear strain at edge of bonded surface due to relative rotation of bearing surfaces
γ	load factor
μ	characteristic coefficient of friction
$\mu_{kmin.}$	characteristic low friction coefficient
μ_a	adverse coefficient of friction
μ_r	relieving coefficient of friction
θ	angle of inclination of opposing bearings
θ_s	half included angle of the curved sliding surface
σ_{ASM}	compressive stress on approved sliding material (ASM)
β	deviation angle from vertical axis of the line of action at the applied load

Subscripts

The above symbols may be qualified by one or more of the following subscripts:

Subscript	Definition
f	value at fatigue limit state
s	value at SLS
u	value at ULS
avg	average
dn	downward component
max	maximum
min	minimum
up	upward component

4.2 Abbreviations

ASM	approved sliding material
ASP	accumulated slide path
CLA	centre-line average
DAF	dynamic amplification factor
FEA	finite element analysis
FRF	frequency response function
IRHD	international rubber hardness degrees
MBEJ	modular bridge expansion joint
MIO	micaceous iron oxide
MSBJ	multiple support bar modular joints
OMV	opening movement and vibration

POM	polyoxymethylene
PTFE	polytetrafluoroethylene
SLS	serviceability limit state
SPO	seal push-out
SSBJ	single support bar modular joints
ULS	ultimate limit state

5 FUNCTIONS OF BEARINGS AND DECK JOINTS

The function of bearings is to provide a special connection to control the interaction of loads and movements between parts of the structure, usually between superstructure and substructure.

The function of deck joints is to provide a trafficable surface across permanent openings in the bridge deck between parts of the deck or between deck and abutments with the widths of such openings varying with environmental effects, loads and movements.

The number of deck joints in a road bridge shall be minimized.

6 LOADS, MOVEMENTS AND ROTATIONS

The load and movement capabilities of bearings and deck joints for any bridge shall be compatible with the assumptions made in the overall design of the bridge and the requirements of this Standard.

The effects of movements of the centre of pressure due to rotation and the moment caused by horizontal loads and friction forces shall be considered in the design of bearings and in the calculation of bearing pressures on substructures and superstructures.

Movements including rotations shall be identified for each of the main axes.

Bridge drawings shall include a diagrammatic plan view of all bearings, by indicating the various actions and degrees of restraint for each bearing by using appropriate symbols.

The loads and movements at the appropriate limit state shall be specified. Testing requirements, including test loads, shall also be specified.

Bearing loads and bridge movements of skewed and curved bridges shall be assessed, including variations of bearing loads across piers and abutments.

Detailing and construction of services, pipelines, railings, parapets and other bridge furniture shall be such as to ensure that movements and rotations of the bridge are not impeded.

7 GENERAL DESIGN REQUIREMENTS

7.1 Design considerations

The following shall be considered in the design of bearings and deck joints:

- Properties of the materials in the structure, including coefficients of thermal expansion, modulus of elasticity, Poisson's ratio, creep and shrinkage.
- Tolerances on material properties, including tolerances on compressive, shear and rotational characteristics.
- Effective temperature range of elements of the bridge.
- Sizes of structural elements.

- (e) Method and sequence of construction including prestressing effects and concrete creep and shrinkage, as relevant.
- (f) Tilt, settlement and movement of piers and abutments.
- (g) Construction tolerances of elements of the bridge and bearings.
- (h) Properties of the bearing in regard to restraints to translation.
- (i) Static and dynamic response of the bridge including traffic, wind, flood, earthquake, collision and ship impact loads.
- (j) Changes to bearing loads due to the longitudinal and transverse effects of temperature gradients in statically indeterminate structures.
- (k) Fatigue requirements.
- (l) Secondary effects resulting from eccentric loads or movements not along bearing axes shall be considered in both the design of the bearing and adjacent structural elements.

NOTE: Additional requirements for modular deck joints are specified in Appendix E.

Where bearings with differing characteristics are used in the same line of support, the resulting interactive effects shall be considered in the design of the bearings and the bridge.

7.2 Specification of bearing design requirements

Non-standard laminated elastomeric bearings and other bearings' performance requirements shall be specified on the drawings.

NOTE: Laminated elastomeric bearings are normally specified by part number. The part number should be chosen from the tables of standard bearings given in Appendix A.

A bearing schedule shall be provided with sufficient information to allow the bearing to be properly designed for all critical load cases.

NOTE: Several load combinations may need to be specified for a particular bearing (e.g. when fatigue loads are to be designed for, where loads due to earthquake effects are significant, when uplift occurs or when special bearing tests are required).

The bearing schedule shall nominate the load combinations for which frictional assistance for anchorage of bearings shall be discounted [e.g. combinations including earthquake effects and other extreme dynamic load fluctuations (see Clause 10.1)].

7.3 Design life

Bearings and deck joints, excluding easily replaceable components such as deck joint seals, shall be designed for a minimum design life of 50 years. Cast-in components shall have the same design life as the bridge.

7.4 Limit state requirements

All bearings and deck joints shall be designed to accommodate the relevant imposed loads, load effects and movements at the required limit states.

ULS movements shall be derived from the nominal movements factored by the relevant load factors specified in AS 5100.2.

Elastomeric bearings shall be designed for SLS effects.

Mechanical bearings shall be designed to accommodate ULS movements and to sustain serviceability and ultimate limit state loads. In addition, mechanical bearings shall remain undamaged after ultimate limit state load testing.

Other types of bearings, sliding contact surfaces and deck joints shall be designed to accommodate ULS movements and to sustain serviceability and ultimate limit state loads without damage, except where relaxation of this requirement is approved by the relevant authority or permitted by other Parts of the AS(AS/NZS) 5100series.

7.5 Provision for construction tolerances

Bearings shall be designed to accommodate the calculated rotation, including an allowance to account for construction tolerances and erection procedure. Where superstructure members are erected directly onto previously prepared bearings, construction tolerance rotation allowance shall be taken as not less than 0.005 radians at SLS for elastomeric bearings and 0.005 radians at ULS for all other bearings. The construction tolerance rotation may be taken as zero where either—

- (a) the superstructure members are initially supported above the bearings and the remaining spaces are then fully grouted; or
- (b) the superstructure is cast directly onto the installed bearing.

7.6 Provision for replacement

Provision shall be made to facilitate the removal and replacement of bearings. Provision shall be made in both the superstructure and substructure design for jacking points. Jacking points and loads shall be shown on the drawings.

Deck joint components subject to wear shall be detailed to facilitate their replacement.

7.7 Provision for resetting

Where it is known that excessive substructure settlements or rotations, or other movements due to mining subsidence or other effects are likely to occur in the life of a bridge, provision for resetting bearings shall be made and the joints shall be designed to accommodate these movements or to facilitate resetting.

7.8 Provision for handling

Suitable handling attachments and lifting points shall be provided for heavy bearings and joints to facilitate handling, placement and location.

7.9 Access

Adequate space shall be provided around bearings and major deck joints to facilitate their inspection, maintenance and replacement.

7.10 Durability

All surfaces of bearings and deck joints shall be protected against corrosion.

Wherever possible, bearings shall be placed on pedestals to protect them against water or dirt spilling from deck joints and against accumulations of dirt and debris.

8 MOVEMENT RESTRAINTS

8.1 General

Where it is required to restrict the movement of a bridge totally, partially or in a selected direction, restraints shall be provided.

NOTE: These restraints may be provided as part of or separate from the bearings, and may take the form of keys, keepers or side restraints.

8.2 Design loads

Restraints shall be designed to resist, at the ULS, either the design load effects or the relevant component of the minimum lateral restraint capacity as specified in AS 5100.2, whichever is the greater.

In addition to forces due to external loads, design load effects due to longitudinal and transverse movements of the superstructure and misalignment of restraints shall be considered.

If restraint against translation is to be provided by several bearings, consideration shall be given to the effects of any clearances between working parts of the bearings and their guides, and the effects of the stiffness of the structure on the distribution of the resulting loads between the bearings.

9 ALIGNMENT OF BEARINGS AND DECK JOINTS

Bearings and deck joints shall be positioned such that they function as assumed in the design.

Bearings shall be set level. Where bearings are required to be set on an incline, allowance shall be made for the longitudinal and transverse components of vertical loads on the bearings.

For all bridges, especially those with wide, skewed or horizontally curved superstructures, due consideration shall be given to the alignment of each bearing in regard to the actual directions of movements and rotations of the superstructure.

10 ANCHORAGE OF BEARINGS

10.1 Pot, spherical and mechanical bearings

Pot, spherical and mechanical bearings shall be anchored at all stages, including construction, by a combination of friction and mechanical anchors. For incrementally launched bridges, bearings may be anchored to the superstructure by friction alone.

The anchorage capacity of these bearings shall be calculated to resist the resultant shear force (H^*) as follows:

$$H^* \leq \phi_f \mu_{kmin} N_{min}^* + \phi R_{ua} \quad \dots 10.1$$

where

ϕ_f = capacity reduction factor for friction
= 0.6

μ_{kmin} = characteristic low friction coefficient for the contact interface as given in Table 10.1; *or* determined by tests to provide 95% probability of exceedance

N_{min}^* = minimum concurrent load acting in compression normal to the bearing anchorage interface calculated in accordance with AS 5100.2

ϕ = capacity reduction factor

ϕR_{ua} = design capacity of mechanical anchors, calculated in accordance with AS 5100.5 or AS/NZS 5100.6, as appropriate

For the design of bearings that incorporate longitudinal or transverse restraints and for the design of separate restraining devices on bridges where extreme dynamic effects can occur, μ_{kmin} shall be taken as zero.

The bearing load schedule shall indicate if friction is not to be accounted for in determining the anchorage capacity of bearings.

The requirement specified in this Clause shall be met for the ULS at all stages, including during construction.

Bridge designers shall specifically indicate if the value of μ_{kmin} shall be taken as zero while producing performance criteria for the bearings.

TABLE 10.1
CHARACTERISTIC LOW FRICTION COEFFICIENT ($\mu_{kmin.}$)
FOR ANCHORAGE OF BEARINGS

Interface	Characteristic low friction coefficient ($\mu_{kmin.}$)
Steel on concrete	0.50
Steel on steel grit blasted, metal zinc sprayed or zinc silicate primed surfaces	0.30
Steel on steel clean mill scale surfaces	0.20
Hot-dip-galvanized surfaces	0.08

10.2 Elastomeric bearings

Elastomeric bearings to be anchored by friction only shall satisfy the requirements of Clause 12.6.7 and the contact surface shall be sufficiently rough to ensure that the friction or restrained force can be developed.

Where frictional restraint, as specified in Clause 12.6.7, is inadequate to restrain the bearing in position and, thus, prevent slippage or crawling, then restraint shall be provided. Restraints shall be removable to allow bearing replacement.

Adhesives including epoxies shall not be used to provide restraint or fixing of elastomeric bearings.

10.3 Restraint of superstructures for earthquakes and accidental impacts

Where the horizontal restraints of conventional bearings are inadequate under earthquake effects or accidental impacts, additional restraining devices, such as ties, shear keys, stops and dowels, shall be provided with the specific aim of preventing dislodgment of the superstructure from the support structure.

11 LOADS RESULTING FROM RESISTANCE TO MOVEMENT

11.1 General

Bearings and deck joints, their connections and associated supporting elements shall be designed to transmit forces arising from resistance to movement due to friction of mechanical and sliding components, and the rotational, compressive and shear stiffnesses of elastomeric elements.

In considering the effects of bearings on structures, the force component due to frictional effects on sliding contact surfaces shall be calculated for permanent effects only.

At ULS, the frictional force shall be calculated using the load factors specified in AS 5100.2.

11.2 Frictional restraint of sliding surfaces

For design purposes, the appropriate characteristic maximum and minimum coefficients of friction (μ) for polished stainless steel sliding on permanently lubricated pure polytetrafluoroethylene (PTFE) at the SLS shall be taken as 0.03 and zero respectively. The characteristic maximum coefficient of friction (μ) for pure unlubricated PTFE on polished stainless steel shall be taken as 0.06.

For alternative approved sliding materials, these friction coefficients shall be validated by laboratory testing for the range of pressures the sliding surface will be subjected to.

11.3 Reaction to sliding of multiple bearings

Where a number of bearings are so arranged that the adverse forces, resulting from reaction to movement by some, are partly relieved by the forces resulting from the reaction to movement by others, the respective coefficients of friction (μ_a) and (μ_r) shall be estimated as follows, unless a more precise investigation has been made:

$$\mu_a = \beta_a \mu \quad \dots 11.3(1)$$

$$\mu_r = \beta_r \mu \quad \dots 11.3(2)$$

where

μ_a = adverse coefficient of friction

μ_r = relieving coefficient of friction

μ = characteristic coefficient of friction for the bearing, as given in Clause 11.2

β_a, β_r = factors dependent on the numbers of bearings n_a and n_r , which are exerting adverse and relieving forces respectively, as given in Tables 11.3(A) and 11.3(B)

TABLE 11.3(A)

VALUES OF β_a

n_a	β_a
≤ 4	1
$4 < n_a < 10$	$1 - \left(\frac{n_a - 4}{24} \right)$
≥ 10	0.75

TABLE 11.3(B)

VALUES OF β_r

n_r	β_r
≤ 4	0
$4 < n_r < 10$	$\left(\frac{n_r - 4}{24} \right)$
≥ 10	0.25

11.4 Shear resistance of elastomeric bearings

For elastomeric bearings where shear movements are accommodated by shear in the elastomer, the shear force (H), due to a movement (δ_s), shall be calculated as follows:

$$H = K_s \delta_s \quad \dots 11.4$$

where

K_s = shear stiffness of an elastomeric bearing

δ_s = maximum resultant vector shear displacement tangential to the bearing surface

12 ELASTOMERIC BEARINGS

12.1 General

This Clause sets out minimum requirements for the design of single unbonded layer (plain pads and strips) and laminated elastomeric bearings.

NOTE: Wherever possible, elastomeric bearings should be selected from standard sizes given in Appendix A, and checked for meeting the criteria of this Standard.

12.2 Physical properties of elastomer

The elastomer used in the manufacture of bridge bearings shall comply with Appendix B. Values of the chord shear modulus (G) and the bulk modulus (B) relevant to the elastomer hardnesses detailed in Appendix B shall be as given in Table 12.2.

For plain pads and strips, the elastomer hardness shall be nominal IRHD 60.

Appropriate values of G and B shall be adopted for alternative elastomer formulations based on appropriate test results.

The physical properties of natural rubber vary significantly at temperatures below -10°C . For areas where the lowest one-day mean ambient temperatures fall below -10°C , variations in the value of G of the elastomer shall be assessed or the use of alternative formulations considered, or both.

TABLE 12.2
ELASTOMER PROPERTIES

Hardness	Chord shear modulus (G)	Bulk modulus (B)
IRHD ± 5	MPa	MPa
50	0.69	2 000
60	0.90	2 000

12.3 General requirements

Laminated elastomeric bearings shall have a side cover of elastomer with a minimum design thickness of 6 mm to protect the edges of the steel plates.

Tolerances for the manufacture of laminated elastomeric bearings shall be as given in Appendix C.

The steel plates shall be bonded to the elastomer during vulcanizing, and the edges of all plates shall be lightly rounded and the corners chamfered. For non-standard bearings having thicker layers of elastomer under high compression, plate thickness shall be checked to ensure that the plate does not fail in tension (see Clause 12.6.6).

Contact surfaces of a bearing shall be constructed at least 50 mm larger around all sides of the bearing.

NOTE: This allows adjustment for positioning the bearings to accommodate construction tolerances.

To ensure adequate edge support, there shall be a minimum clearance of 20 mm.

Relatively large tolerances shall be provided to meet the specified stiffness properties of elastomeric bearings and also inherent variations of stiffness that occur in elastomers with variations of strain. Where strain is significant, the effects of these tolerances and variations shall be considered in the design of the structure. They may be assumed to be of the total order of $\pm 20\%$.

12.4 Design principles

12.4.1 General

Elastomeric bearings shall be designed to resist SLS loads and movements.

12.4.2 Bearing rotations

The structural elements of the bridge shall be detailed with the objective that, at completion of construction, the loaded faces of the elastomeric bearing are parallel.

The elastomeric bearing shall then be designed to accommodate rotations due to traffic loading and other transient effects, thermal effects and long-term permanent effects in combination with an initial lack-of-parallelism due to construction tolerances.

12.5 Basis of design

12.5.1 General

Elastomeric bearings accommodate translation and rotation by elastic deformation. The deflection of the elastomer under compressive load is influenced by its shape. Where reinforcing plates are bonded to the elastomer, the design shall be based on the assumption that there is no relative movement at the steel and elastomer interface.

The design of elastomeric bearings shall be in accordance with Clause 12.6. Special consideration shall be given in the design for pads, strips and laminated elastomeric bearings with shape factors outside the limits specified in Clause 12.5.2.

12.5.2 Shape factor

The shape factor (S) of a layer of elastomer shall be the area under compression divided by the area free to bulge, and shall be calculated for layers without holes as follows:

(a) *For laminated elastomeric bearings:*

$$S = \frac{A_b}{Pt_e} \quad \dots 12.5.2(1)$$

where

A_b = bonded surface area

P = surface perimeter

t_e = effective thickness of the individual elastomer layer in compression (due to vertical load or rotation)

= t_i for an inner layer ... 12.5.2(2)

= $1.4t_c$ for a cover layer ... 12.5.2(3)

t_i = thickness of the individual inner layer of elastomer in laminated elastomeric bearing

t_c = thickness of a cover layer of laminated elastomeric bearing

(b) *For plain pad bearings:*

$$S = \frac{A_r}{Pt_e} \quad \dots 12.5.2(4)$$

where

A_r = total rubber plan area

t_e = $1.8t$... 12.5.2(5)

t = total thickness of elastomer in laminated elastomeric bearing or thickness of plain pad or strip bearing

(c) For strip bearings:

$$S = \frac{w}{2t_e} \quad \dots 12.5.2(6)$$

where

w = width of strip

$$t_e = 1.8t \quad \dots 12.5.2(7)$$

Where dowel holes are to be provided, a special assessment of the shape factor (S) shall be made, allowing for the holes and the restraint to bulge provided by the dowels.

For the design criteria specified in Clause 12, the shape factor (S) shall be as follows:

- (i) For plain pads and strips $1 \leq S \leq 4$.
- (ii) For internal layers of laminated elastomeric bearings $4 \leq S \leq 12$.

12.6 Design requirements

12.6.1 Maximum shear strain in laminated elastomeric bearings

To ensure that the total shear strain developed in the elastomer is not excessive, the following requirement at the edge of the bonded surface shall be satisfied:

$$\varepsilon_{sc} + \varepsilon_{sr} + \varepsilon_{sh} \leq \frac{2.6}{\sqrt{G}} \quad \dots 12.6.1(1)$$

where

ε_{sc} = shear strain at edge of bonded surface due to loads normal to bearing surfaces

ε_{sr} = shear strain at edge of bonded surface due to relative rotation of bearing surfaces

ε_{sh} = shear strain at edge of bonded surface due to forces tangential to the bearing surface or movement of the structure, or both

The values of shear strains shall be calculated as follows:

$$\varepsilon_{sc} = 6S\varepsilon_c \quad \dots 12.6.1(2)$$

where

ε_c = compressive strain due to loads normal to the bearing surfaces [based on the effective loaded plan area (A_{eff})]

$$= \frac{N}{3A_{eff}G(1+2S^2)} \quad \text{for internal layers only} \quad \dots 12.6.1(3)$$

N = compressive load on a bearing, SLS

A_{eff} = effective loaded plan area, nominally equal to the projected area common to top and bottom when a bearing is distorted tangentially

$$= A_b \left(1 - \frac{\delta_a}{a} - \frac{\delta_b}{b} \right) \quad \text{for rectangular bearings} \quad \dots 12.6.1(4)$$

$$= A_b - \delta_s d \quad \text{for circular bearings} \quad \dots 12.6.1(5)$$

δ_a = maximum shear displacement tangential to bearing surface in the direction of dimension a due to movements of the structure and tangential forces

a = plan dimension of the edge of the bonded surface of rectangular bearings parallel to the span of the bridge

δ_b = maximum shear displacement tangential to bearing surface in the direction of dimension b due to movements of the structure and tangential forces

b = plan dimension of the edge of the bonded surface of the rectangular bearing transverse to the span of the bridge

δ_s = maximum resultant vector shear displacement tangential to the bearing surface

d = plan diameter of circular bearing at edge of bonded surface

$$\varepsilon_{sr} = \frac{\alpha_a a^2 + \alpha_b b^2}{2t_i t} \quad \text{for rectangular bearings} \quad \dots 12.6.1(6)$$

$$= \frac{\alpha d^2}{2t_i t} \quad \text{for circular bearings} \quad \dots 12.6.1(7)$$

$$\varepsilon_{sh} = \frac{\delta_s}{t} \quad \text{for all bearings} \quad \dots 12.6.1(8)$$

α_a = angle of rotation parallel to the span of the bridge

α_b = angle of rotation transverse to the span of the bridge

α = maximum angle of rotation, that is, change in angle between top and bottom surfaces of bearing in critical direction

t_i = thickness of an individual inner layer of elastomer in a laminated bearing

12.6.2 Compressive stress on elastomeric bearings

The mean compressive stress on elastomeric bearings shall be determined as follows:

- The mean compressive stress (N/A_b) on laminated elastomeric bearings shall be not greater than 15 MPa.
- The mean compressive stress (N/A_r) on plain pad and strip bearings shall be not greater than the lesser of $2GS$ or 5 MPa.

12.6.3 Shear strain due to tangential movements and forces

To limit tangential distortion and to minimize rolling of the edges of the bearings or tendency of the steel plates to bend, the following shall be satisfied:

$$\varepsilon_{sh} \leq 0.5$$

In the determination of ε_{sh} the deflections due to earthquake and braking need not be considered.

The tangential movements and forces shall not reduce the projected plan area common to the top and bottom faces of a bearing by more than 20%, that is—

- $A_{eff} \geq 0.8A_b$ for laminated elastomeric bearings; and
- $A_{eff} \geq 0.8A_r$ for plain pads and bearing strips.

12.6.4 Rotational limitation

For plain pads and laminated elastomeric bearings, the total compressive deflection (d_c) shall satisfy the following:

(a) *For rectangular bearings:*

$$d_c \geq \frac{\alpha_a a + \alpha_b b}{3} \quad \dots 12.6.4(1)$$

(b) *For circular bearings:*

$$d_c \geq \frac{\alpha d}{3} \quad \dots 12.6.4(2)$$

(c) *For plain strip bearings:*

$$d_c \geq \frac{\alpha_a w}{3} \quad \dots 12.6.4(3)$$

where

d_c = total compressive deflection

α_a = angle of rotation parallel to the span of the bridge

a = plan dimension of the edge of the bonded surface of rectangular bearings parallel to the span of the bridge

α_b = angle of rotation transverse to the span of the bridge

b = plan dimension of the edge of the bonded surface of a rectangular bearing transverse to the span of the bridge

α = maximum angle of rotation, that is, change in angle between top and bottom surfaces of bearing in critical direction

d = plan diameter of circular bearing at edge of bonded surface

w = width of strip

12.6.5 Stability of bearings

The stability of bearings shall be determined as follows:

(a) *Plain pad and strip bearings* For plain pad and strip bearings, the thickness shall be not greater than one quarter of the least lateral dimension.

(b) *Laminated elastomeric bearings* For laminated elastomeric bearings supporting a bridge superstructure that is free to translate horizontally, the compressive load on each bearing (N) shall satisfy the following:

$$N \leq \frac{2b_e GSA_{\text{eff}}}{3t} \quad \dots 12.6.5$$

where

b_e = lesser of a and b for rectangular bearings

= diameter (d) for circular bearings

S = shape factor of the thickest inner layer

For bearings supporting a bridge superstructure that is fixed against horizontal translation both longitudinally and transversely, the stability limit may be increased by 50%.

12.6.6 Thickness of metal plates

The minimum thickness of metal plates (t_s) in elastomeric bearings shall conform to the following:

$$(a) \quad t_s > \frac{3Nt_i}{A_b f_y}; \text{ and} \quad \dots 12.6.6(1)$$

$$(b) \quad t_s \geq 5 \text{ mm} \quad \dots 12.6.6(2)$$

NOTE: For replacement of bearings, the thickness of the steel plates in the replacement bearings may match the existing bearings.

where

f_y = yield strength of the metal plate

For steel plates with dowel holes, f_y shall be factored by 0.5.

12.6.7 Fixing of bearings

Elastomeric bearings in direct contact with a metal plate shall be mechanically restrained.

Under the provisions of Clauses 10.2 and 10.3, bearings may be restrained by friction only, provided that under all SLS load combinations—

$$N_{\min.} \geq 10H - 2f_o A_{\text{eff}} \quad \dots 12.6.7(1)$$

where $N_{\min.}$ is the minimum permanent compressive load normal to the bearing anchorage interface concurrent with H , and under permanent loads only—

$$N_{\min.PE} \geq 2.2f_o A_b \quad \dots 12.6.7(2)$$

where

$N_{\min.PE}$ = minimum compressive load, due to permanent load effects, normal to the bearing anchorage interface concurrent with H

f_o = stress used in calculation of anchorage of laminated elastomeric bearing
= 1.0 MPa

12.6.8 Compressive deflection

The total compressive deflection (d_c) of the bearing shall be determined as follows:

$$d_c = \Sigma(t_n \varepsilon_c) \quad \dots 12.6.8(1)$$

The value of the compressive strain (ε_c) in a layer of a laminated elastomeric bearing to be used in deriving the compressive deflection (d_c) shall be determined as follows:

$$\varepsilon_c = \frac{N}{E_c A_b} \quad \dots 12.6.8(2)$$

where

E_c = effective compression modulus of elastomer, as calculated for an individual layer of a laminated elastomeric bearing

$$= E_h + \left[\frac{C_1 G S^2}{1 + \left(\frac{C_1 G S^2}{0.75 B} \right)} \right] \quad \dots 12.6.8(3)$$

C_1 = a constant dependent on the bearing shape

E_h = homogeneous compression modulus, calculated as follows:

(a) *For rectangular bearings:*

$$E_h = 4G \left[1 - \left(\frac{q}{1+q^2} \right)^2 \right] \quad \dots 12.6.8(4)$$

$$C_1 = 4 + q(6 - 3.3q) \quad \dots 12.6.8(5)$$

where

$$q = \text{ratio} \\ = a/b; \text{ or} \quad \dots 12.6.8(6)$$

$$= b/a, \text{ whichever is the lesser} \quad \dots 12.6.8(7)$$

(b) *For circular bearings:*

$$E_h = 3G \quad \dots 12.6.8(8)$$

$$C_1 = 6$$

(c) *For plain pads and strips:*

The value of the compressive strain (ε_c) to be used in deriving the total compressive deflection (d_c) shall be determined as follows:

$$\varepsilon_c = \frac{N}{A_r \left[16GS + 2 \left(\frac{N}{A_r} \right) \right]} \quad \dots 12.6.8(9)$$

12.7 Bearing stiffnesses

12.7.1 Compressive stiffness

The compressive stiffness of a bearing (K_c) shall be determined as follows:

$$K_c = \frac{1}{\Sigma \left(\frac{1}{K_{cn}} \right)} \quad \dots 12.7.1(1)$$

where

K_{cn} = compressive stiffness of an individual layer n of elastomer in a laminated bearing

$$= \frac{E_c A_b}{t_n} \quad \dots 12.7.1(2)$$

E_c = see Clause 12.6.8

t_n = thickness of a typical layer n of elastomer

12.7.2 Shear stiffness

The shear stiffness of an elastomeric bearing (K_s) shall be determined as follows:

$$K_s = \frac{A_r G}{t} \quad \dots 12.7.2$$

The value of t shall be adjusted to allow for any layers of rubber not free to shear.

The value of the shear stiffness (K_s) of an elastomeric bearing under varying compressive or shear stresses, or both, may be calculated from Equation 12.7.2 using G as defined in Clause 12.2.

12.7.3 Rotational stiffness

The rotational stiffness of a bearing (K_r) shall be the rotational moment (M) to produce unit rotation and determined as follows:

- (a) Rotational stiffness of a layer n (K_m) of a laminated elastomeric bearing:

$$K_m = \frac{M}{\alpha} = \frac{E_r I}{t_n} \quad \dots 12.7.3(1)$$

where

M = rotational moment

I = second moment of area of the plan area of the bonded elastomer about its axis of rotation

- (i) For individual layers of laminated elastomeric bearings:

$$E_r = E_h + \left[\frac{C_2 G S^2}{1 + \left(\frac{C_2 G S^2}{0.75 B} \right)} \right] \quad \dots 12.7.3(2)$$

C_2 = constant dependent on the bearing shape

- (ii) For rectangular bearings:

$$E_h = 4G \left[1 - \left(\frac{m}{m^2 + 1} \right)^2 \right] \quad \dots 12.7.3(3)$$

$$C_2 = 4 - \left[\frac{32}{10 + m(4 + 3m + m^2)} \right] \quad \dots 12.7.3(4)$$

m = ratio of the sides of a rectangular laminated elastomeric bearing

= a/b for rotation about an axis parallel to the long dimension of the bearing

- (iii) For circular bearings:

$$E_h = 3G \quad \dots 12.7.3(5)$$

$$C_2 = 2 \quad \dots 12.7.3(6)$$

- (b) Total rotational stiffness of bearing (K_r):

$$K_r = \frac{1}{\sum \left(\frac{1}{K_m} \right)} \quad \dots 12.7.3(7)$$

where

E_r = effective rotation modulus of elastomer

G = chord shear modulus, between 5% and 25% shear strain for an elastomer

S = shape factor of the thickest inner layer

12.7.4 Inclined elastomeric bearings

Elastomeric bearings shall be installed level. Strip, plain pad and laminated elastomeric bearings may be installed on an incline, provided the following criteria are met:

- (a) The strip, plain pad or laminated elastomeric bearing is mechanically restrained on both the top and bottom faces.

and

- (b) The shear deflection of the bearing caused by the application of the self-weight of the superstructure is less than 6 mm. Where the bearing is inclined about both axes, the shear deflection shall be taken as the vector sum of the longitudinal and transverse deflection.

NOTE: The designer should be aware that the lateral stiffness of elastomeric bearings can be quite low and the component of force parallel to the incline may result in significant movement. Additional restraints may be required both during construction and in service to control short-term and long-term deflections.

Inclined elastomeric bearings may also be used in opposed pairs of identical bearings to permit an increased transverse shear stiffness of the pair of bearings without increasing the longitudinal shear stiffness or vice versa. First principles shall be used to determine the combined effects.

The effective lateral horizontal stiffness (K_h) of a pair of identical bearings of shear stiffness (K_s) and compressive stiffness (K_c), if opposed at an angle (θ) to the horizontal, shall be calculated as follows:

$$K_h = 2K_c \sin^2 \theta + 2K_s \cos^2 \theta \quad \dots 12.7.4(1)$$

where θ is the angle of inclination of the opposing bearings.

Similarly, the effective compression stiffness (K_v) shall be calculated as follows:

$$K_v = 2K_c \cos^2 \theta + 2K_s \sin^2 \theta \quad \dots 12.7.4(2)$$

To prevent lift-off in one of the pair of bearings, it shall be ensured that—

$$\frac{N}{H} > \frac{K_c \tan \theta}{K_c \tan^2 \theta + K_s} \quad \dots 12.7.4(3)$$

provided $\theta < 5^\circ$.

Where significant transverse rotation of the superstructure occurs at the bearings due to eccentric load effects, the effective value of K_h shall be reduced as follows:

$$K_h = \frac{2K_c K_s}{K_c \cos^2 \theta + K_s \sin^2 \theta} \quad \dots 12.7.4(4)$$

Excessive tensions may develop in the bearings due to superstructure rotations, especially if the compressive deflections are not sufficient. In this case, overall performance of the bearing assembly shall be assessed from first principles.

12.8 Creep

Long duration loads introduce time-dependent effects in elastomers through creep and stress relaxation.

For most applications, the effects of creep and stress relaxation need not be considered. However, when considering new formulations and synthetic rubber, creep tests shall be performed.

NOTES:

- 1 For natural rubber, maximum compressive creep values of about 25% of the instantaneous deformation may be used.
- 2 Creep effects are logarithmic functions of time and are also dependent on temperature, stress history and elastomer formulation.

12.9 Load testing of elastomeric bearings

All laminated bearings shall be load-tested in compression to 1.5 times the rated load at zero shear and zero rotation.

Compressive and shear stiffness testing shall be on representative samples of bearings. The actual number of bearings checked for stiffness shall be determined by quality control procedures and previous test data.

When acceptance tests for shear stiffness are required or when determining effective values of G , bearings shall be subjected to a mean compressive stress of 2 MPa and the shear stiffness or value of G , derived from the mean shear stiffness, measured between 5% and 25% shear strain.

Testing laminated elastomeric bearings shall be in accordance with Appendix D.

Representative samples of plain pad and strip bearings shall be subjected to compressive load tests to 1.5 times the design vertical force (Q^*).

13 POT BEARINGS

13.1 Design

The components of pot bearings, including associated sliding contact surfaces, shall be designed for ULS effects.

The following primary design parameters and fabrication details of pot bearings shall be adopted:

- (a) The maximum mean compressive stress on the elastomer shall be 50 MPa.
- (b) The thickness and formulation of the elastomer shall depend on the required rotational capacity and the smoothness of the inner surface of the pot; however, in no case shall the total pad thickness be less than the larger of one fifteenth of the diameter of the elastomeric pad or 10 mm.
- (c) The maximum displacement due to the ULS rotation at the perimeter of the elastomeric pad shall be not greater than 15% of the total pad thickness, including sealing rings.
- (d) To prevent extrusion of the elastomer, the pot shall incorporate a seal around the top corner of the elastomeric disc. The internal seal shall be either a set of brass rings, POM chain or a carbon-filled PTFE seal complying with requirements of EN 1337-5.

The maximum accumulated slide path (ASP) of the internal seals, defined as the sum of the relative movements of the seal on the pot wall due to cycles of rotation of the bearing caused by traffic loading shall be taken to be 2000 m for POM chain and carbon-filled PTFE seals and 1000 m for brass rings.

Pot bearings with metallic seals shall not be used for rail bridges or for road bridges where the number of vehicles per lane per day is predicted to exceed 1000 in the first year of service, where the number of vehicles per lane per day is as defined for road traffic fatigue loads in AS 5100.2.

- (e) Pot bearings shall be anchored in accordance with Clause 10.1 and, where required, movement restraints shall be provided in accordance with Clause 8.

- (f) If required, provision for horizontal movements shall be provided by a sliding surface in accordance with Clause 14.

Pot bearings shall be designed to accommodate the calculated ultimate rotation including an allowance to account for construction tolerances and erection procedure.

The load and rotation capacity of pot bearings shall be tested in accordance with Clause 13.2.

NOTE: Pot bearings are normally supplied as a proprietary product where the detailed design of the bearings is the responsibility of the manufacturer.

13.2 Load testing

Bearings shall be tested for compliance with the specified performance and load testing requirements, and shall meet the relevant requirements of this Standard.

At least 1 in 10, or part thereof, of each type of bearing shall be tested to confirm that the design and fabrication of the bearings are acceptable.

Bearings that are to be tested shall be separately load-tested as follows:

- (a) In compression, to the maximum ultimate compressive load.
- (b) In shear, to the maximum ultimate lateral shear load (vector sum in the case of fixed bearings) in conjunction with the concurrent maximum ultimate compressive load.
- (c) In shear, to the maximum ultimate lateral shear load (vector sum in the case of fixed bearings) in conjunction with the concurrent minimum ultimate compressive load.

NOTE: For bearing subject to uplift, see Clause 16.

- (d) In rotation, to the maximum ultimate rotation with 0.7 times the maximum ultimate compressive load.

After load-testing, the bearing shall be dismantled and examined for rubber extrusion, PTFE damage, warping, scoring or other effects that may affect the durability of the bearing.

13.3 Bearing identification and movement scale

Bearings shall be fitted with a nameplate indicating the manufacturer, bearing model or type, year of manufacture and the design vertical load.

In addition, bearings incorporating a sliding contact surface shall specify the movement capacity, as appropriate.

A movement scale and pointer shall be fitted to nominated bearings so as to be clearly visible on the installed bearings.

14 SPHERICAL APPROVED SLIDING MATERIAL (ASM) BEARINGS

14.1 General

A spherical ASM bearing is a bearing consisting of a backing plate with a convex spherical surface and a backing plate with a concave spherical surface between which a sliding material and the mating material form a curved sliding surface.

Spherical ASM bearings may be used in combination with flat sliding elements and guides to form free sliding and guided sliding bearings. Spherical ASM bearings combined with a plane sliding surface may be used together with a restraining ring to form fixed bearings.

NOTE: Examples of spherical bearings combined with flat sliding elements are given in Figure 14.1.

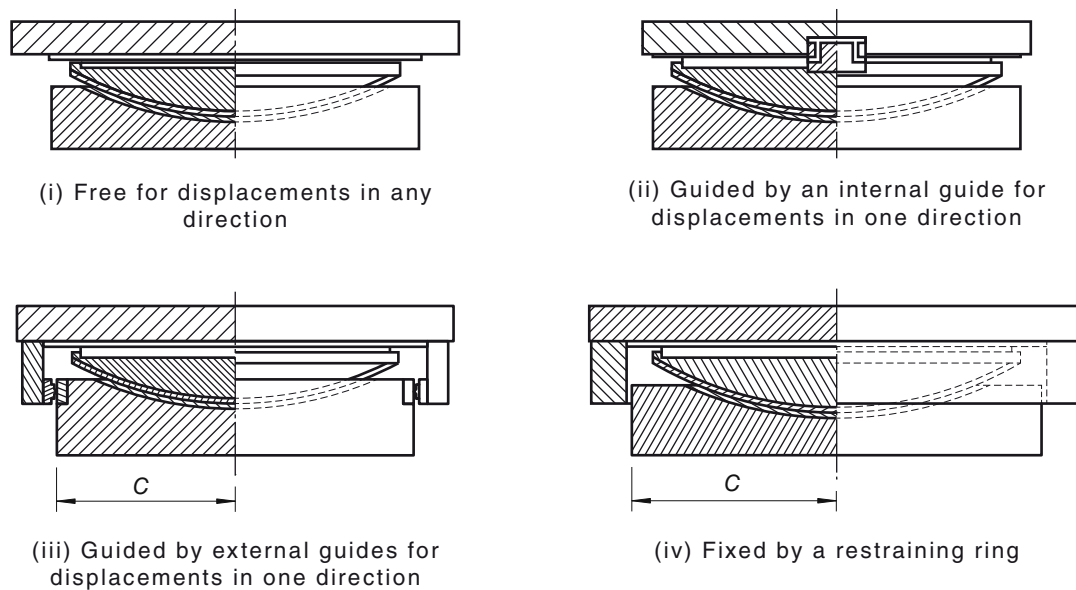


FIGURE 14.1 SPHERICAL BEARINGS COMBINED WITH FLAT SLIDING ELEMENTS

14.2 Design

The components of spherical bearings, including associated sliding contact surfaces, shall be designed for ULS effects.

The compressive stresses on ASM at the ULS shall be not greater than the values demonstrated by suitable testing and shall not exceed the values given below without the approval of the relevant authority. Where the bearing temperature may exceed 35°C, the allowable bearing pressure shall be reduced by an appropriate factor approved by the relevant authority.

The following primary design parameters and fabrication details of spherical bearings shall be adopted:

- The maximum mean compressive stress on the projected reduced area of the spherical contact surface shall be 120 MPa.
- The maximum contact stress under or above a spherical bearing shall be in accordance with Clause 17.
- Spherical bearings shall be anchored in accordance with Clause 10.1 and, where required, movement restraints shall be provided in accordance with Clause 8.
- Curved sliding contact surfaces of a spherical bearing shall comply with Clause 14.5.
- Plane sliding contact surfaces of a spherical bearing shall comply with Clause 15.
- If required, provision for horizontal movements shall be provided by a sliding surface in accordance with Clause 15.

Spherical bearings shall be designed to accommodate the calculated ultimate rotation about any axis including an allowance to account for construction tolerances and erection procedure. They shall be capable of transferring the specified forces between the superstructure and substructure.

The load and rotation capacity of spherical bearings shall be tested in accordance with Clause 14.3.

NOTE: Spherical bearings are normally supplied as a proprietary product where the detailed design of the bearings is the responsibility of the manufacturer.