Sub: Guidelines on spherical bearings including provisions for maintenance

Bearsings are provided on bridges for permitting longitudinal, lateral and rotational movements of bridge girders and also transfer of load to substructure and foundation. Conventionally we have been using steel sliding bearing and roller rocker bearings. Subsequently we have started using Neoprene and POT-PTFE bearing. The next generation bearings are spherical bearings which provide better movement and load transfer ability to bridge structure. They can also be a good solution where large size forces are to be efficiently transferred to substructure. Use of these bearings is quite common in advance countries. These guidelines have been prepared after detailed literature survey European codes and in consultation with experts in the field. These are broad guidelines for use in field where ever the need arise. Any comments or suggestions for improvement are most welcome. The suggestions are also welcome from any engineer dealing with design, maintenance and supply of bridge bearing or technical institutes.

(Sumeet Singhal)
Director (B&S)/SB-I
for Director General

Copy to:

Director, Indian Railway Institute of Civil Engg., Pune-411 001.
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1.0 Scope

This guideline deals with the requirements for the materials, design, manufacture, testing, installation and maintenance of Spherical & Cylindrical Bearings for Bridges. The provisions of this guideline are meant to serve as a guide to both design & construction engineers, but mere compliance with the provisions stipulated herein will not relieve them in any way of their responsibility for the performance & soundness of the product in the structure.

The provisions of this guideline shall apply for operating temperature between -15 °C and +50 °C. The provisions made in this guideline are based on an assumed working life of the Spherical Bearing of 35 years.

Bearings which are subjected to Tensile Loads are beyond the scope of this guideline as requiring special arrangement / configuration. Established guidelines & Specifications worldwide may please be referred for such Bearings. However this guideline may be considered as a guide for general purpose in such cases.

Spherical & Cylindrical Bearings with an included angle (2θ) greater than 60° and 75° respectively are beyond the scope of this guideline.

Sliding surfaces with a diameter of the circumscribing circle of PTFE or UHMWPE sheets less than 75 mm or greater than 1500 mm are beyond the scope of this guideline.

Spherical Bearings and Cylindrical Bearings for use as temporary devices during construction, for example during launching of the super-structure, are also beyond the scope of this guideline. However this guideline may well be considered as a guide to these cases.
2.0 Definition of product and intended use

2.1 Definition of the Product

Spherical Bearing

The Spherical Bearing is a structural bearing which consists of a set of concave & convex mating steel backing plate with a low friction sliding interface in between thereby permitting rotation by in-curve sliding. For the purpose of providing the movement ability, the bearings may be combined with flat sliding elements, guides and restraining rings.

Figure 1 - Spherical Bearing

a) Free for displacement in any direction  b) Internally guided in one direction

c) Externally guided in one direction  d) Fixed by a restraining ring

Figure 2 - Spherical Bearings combined with flat sliding elements
Cylindrical Bearing

The Cylindrical Bearing consists of a metal backing plate having a concave cylindrical surface affixed with a low friction sliding interface to provide friction less sliding against the mating material from another backing plate with a matching convex cylindrical surface. Cylindrical Bearings are also used in combination with flat sliding elements and guides to form free or guided bearings.

Figure 3 — Cylindrical Bearings

Figure 4 — Cylindrical bearings combined with flat sliding elements
2.2 Intended use

Spherical & Cylindrical Bearings are suitable for all types of structures but especially for soft structures with relatively large and frequent displacements caused by variable loads, and for superstructures that induce fast sliding displacements in bearings, e.g. in bridges for the railways.

3.0 Terms of Reference & Symbols

3.1 Terms & Definition

Base Plate

Steel Plates of the Bearing Assembly at Top & Bottom interfaced with the structure Concrete / Steel member.

Backing Plate

Steel Plates confining the low friction sliding material like PTFE etc.

Guides

Metallic projection from the top plate getting locked with the adjacent steel component or vice versa thereby restraining the movement of the bearing in the direction perpendicular to that.

Mating Surface

Flat or curved hard smooth surface of stainless steel, polished steel or chrome plated sliding against the PTFE or other low friction thermoplastic material.

Sliding Surface

PTFE or UHMWPE low friction thermoplastic material mounted on flat or curved backing plate providing low friction sliding to the mating surface.

Sliding Interface

Combination of mating & sliding surfaces providing relative low friction sliding displacement.

3.2 Symbols

The commonly used symbols are defined here-below. For unique & specific symbols used in the expressions in further clauses of this guidelines are defined at their occurrence.

A  geometrical area of flat and projected area for curved sliding surface
L  diameter or diagonal of the projected area of sliding surface
r  radius of curvature of the curved sliding surface
N  axial or normal force
V  lateral or shear force
a  minor side of the projection in plan of cylindrical sliding surfaces
b  major side of the projection in plan of cylindrical sliding surfaces / distance from the projected area of the curved sliding surface
c  dimension
4.0 Material Specification

4.1 Steel for backing plates

Mild Steel plates in accordance with IS: 2062 Grade B, cast steel in accordance with IS 1030 Grade 280-520W or 340-570W. Stainless steel in accordance with AISI 304 / 316 shall be used for the backing plates with flat or curved surfaces, as appropriate. Equivalent or superior grades as per other national & international specification with proven performance and suitability to application requirements shall also be acceptable.

4.2 Low Friction Thermo-plastic Sliding Material (PTFE or UHMWPE)

The material shall be either pure polytetrafluoroethylene (PTFE), free sintered, without regenerated materials and fillers or Ultra High Molecular Weight Polyethylene (UHMWPE) having high material strength and low frictional properties. The detailed specification regarding the material, mechanical & physical properties, design, manufacture & test requirements shall be as described in Annexure – A “Properties of Low Friction Sliding Material”. The sliding surface shall be recessed in the metal backing plate and bonded, if required. The surface of sliding surface to be in contact with metal plate shall be chemically etched for proper bonding, if required.
Modified or composite sliding material having frictional properties superior to that of PTFE combined with enhanced load bearing capacity and ability to provide high velocity displacement with longer service life is encouraged and shall be permitted for both Primary (flat or curved) and secondary (guides) sliding interfaces. However, this shall be subject to the availability of the records of its acceptance and approval by Leading International Specifications, satisfactory & proven test & performance records.

4.3 Reduction factor, \( k \) to reduce Creep Effects

The characteristic compressive strengths of PTFE / UHMWPE are given in Table 1 and valid for effective bearing temperatures up to 30 °C for PTFE and 35 °C for UHMWPE. For bearings exposed to a maximum effective bearing temperature in excess of above mentioned respective values, the aforementioned values shall be reduced by 2 % per degree above 30 °C / 35 °C in order to reduce creep effects of the PTFE / UHMWPE respectively.

<table>
<thead>
<tr>
<th>Material</th>
<th>Application</th>
<th>( f_k ) (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE</td>
<td>Main Bearing Surface – Permanent &amp; Variable Loads</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Guides – Permanent &amp; Variable Loads</td>
<td>60</td>
</tr>
<tr>
<td>UHMWPE</td>
<td>Main Bearing Surface – Permanent &amp; Variable Loads</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Guides – Permanent &amp; Variable Loads</td>
<td>120</td>
</tr>
</tbody>
</table>

4.4 Austenitic Steel

Stainless Steel for the sliding Interface shall be in accordance with AISI 316L or O2Cr17Ni12Mo2 of IS: 6911. The thickness of the Stainless Steel sheet shall be 3 mm min. The Stainless Steel sheet shall be attached to its backing plate either by screwing / riveting or by continuous fillet weld.

The minimum thickness of austenitic steel sheet shall be 3 mm.

Care shall be taken to ensure that the austenitic steel sheet is fully in contact with the backing plate over the area which will be in contact with the sliding surface. To avoid the danger of air entrapment, air releasing spots of max 10 mm length on two opposite sides may be provided while attaching the stainless steel sheet to the backing plate by continuous fillet weld.

While attaching the austenitic steel sheet by screwing, counterpunched screwing and riveting, corrosion resistant fasteners compatible with the austenitic steel sheet shall be used for securing its edges. They shall be provided at all corners and along the edges outside the area of contact with the sliding surface with the maximum spacing limited to 300 mm Intermediate & 50 mm at the edges.

4.5 Hard chromium plated surfaces

The entire curved surface of the convex steel plate mating with concave sliding surface shall be hard chromium plated. Hard chromium plating and the surface of its base shall be free from surface porosity, shrinkage cracks and inclusions. Small defects may be repaired e.g. by pinning prior to hard chromium plating.

The thickness of the hard chromium plating shall be at least 100 µm and the final surface roughness of the plated surface shall not exceed 3 µm.
Both the base material and hard chromium plating may be polished to achieve the finish less than the specified surface roughness.

4.6 Material combinations

The permissible combination of the materials (sliding & mating surfaces) to be used for sliding interfaces shall be as given in Table 2 below. The sliding surface shall be lubricated in accordance with Clause 4.8.

Table 2: Permissible combination of materials for permanent applications as sliding interfaces for spherical bearings

<table>
<thead>
<tr>
<th>Plane surface</th>
<th>Curved surface</th>
<th>Guides</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE / UHMWPE (dimpled)</td>
<td>PTFE / UHMWPE (dimpled)</td>
<td>PTFE / UHMWPE / POM (un-dimpled)</td>
</tr>
<tr>
<td>austenitic steel</td>
<td>austenitic steel</td>
<td>austenitic steel</td>
</tr>
<tr>
<td>hard chromium plating</td>
<td>Composite Material (CM1 &amp; CM2)</td>
<td></td>
</tr>
</tbody>
</table>

4.7 Composite material

As an alternative for strips in guides, the composite material of type CM1 & CM2 having properties as per Annexure – B can also be used.

4.8 Lubricant

The Lubricant will reduce the frictional resistance and wear of the low friction sliding material and its properties shall be retained through service range of temperature. The Lubricant properties shall be as described in Table 3 below:

Table 3 - Physical and Chemical Properties of lubricants

<table>
<thead>
<tr>
<th>Properties</th>
<th>Testing Standard</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked penetration</td>
<td>ISO 2137</td>
<td>26.5 to 29.5 mm</td>
</tr>
<tr>
<td>Dropping point</td>
<td>ISO 2176</td>
<td>≥ 180 °C</td>
</tr>
<tr>
<td>Oil separation after 24 h at 100°C</td>
<td>Annex G of Eurocode EN 1337-2: 2003</td>
<td>≤ 3 % (mass)</td>
</tr>
<tr>
<td>Oxidation resistance pressure drop after 100h 160°C</td>
<td>Annex H of Eurocode EN 1337-2: 2003</td>
<td>≤ 0.1 MPa</td>
</tr>
<tr>
<td>Pour-point of base oil</td>
<td>ISO 3016</td>
<td>Below - 60 °C</td>
</tr>
</tbody>
</table>

4.9 Anchoring Arrangement

Positive anchoring arrangement by way of bolts passing through bearing component & anchored to Dowels / Steel distribution plates shall be adopted for all Bearings.
4.10 Corrosion Protection

All exposed steel surfaces including backing plates shall be made free from rust and rust inducing contaminants by shot blasting to SA 2 ½ roughness and protected against corrosion by a suitable method such as galvanizing or zinc rich epoxy paint etc. as per manufacturers specification. However, the thickness of such protective layer including the prime & top coats shall be 150 µm min.

5.0 Design Requirements

5.1 General

Loads, forces, movements and rotation to be considered in designing the bearings shall be determined by suitable global analysis of the structure with idealized boundary condition under any critical combination that can coexist. Resistance due to friction at the sliding interface of the bearing shall be ignored for idealizing the boundary conditions. However, induced force generated due to friction at sliding interface shall be considered in the design of bearings and adjacent (supported / supporting) structures.

Coexisting values of loads, forces & movement data for design of bearings shall be furnished for both Service & Ultimate Limit state condition for each type of bearings separately in the format given in Annexure – C “Bridge Bearing Design Questionnaire Form”.

The designer of bridge superstructure shall provide the forces required to be transferred to substructure. The design of bearing should normally be done by bearing manufacturers and get it approved from the client (i.e. bridge designer) or his representative.

Bearing manufacturer shall give the guarantee for satisfactory performance of bearing for appropriate period keeping in view the design life of bearing.

5.2 Rotation capability

The following criteria shall be satisfied for all design conditions:

i) The Hard Chromium Plated convex mating surface shall cover the concave sliding surface fully under full design rotation.

ii) There shall be no contact (seizure) of concave & convex or any other metallic component of the Bearings under full design rotation.

For the verification of the above conditions, the nominated design rotation value shall be increased by \( \pm 0.005 \) radians or \( \pm \frac{10}{r} \) radians, whichever is greater. \((r = \text{radius of the component being checked in mm})\)

5.3 Displacement capacity

The following criteria shall be satisfied for all design conditions:

i) The stainless steel mating surface shall cover the flat sliding surface fully under full design displacement.

ii) The sliding interface shall not cease or become unstable before providing the full design displacement.
For the verification of the above conditions, the nominated design movement requirement shall be increased by +20 mm in both directions of movement with a min. total movement of +50 mm in bridge longitudinal direction and +25 mm in the bridge lateral direction unless restrained.

**NOTE:-** The increase in rotation & movement requirements as stated above shall however be applicable only for the purpose of calculating the practical rotational clearances between the components and movement capabilities without ceasing or failure and shall not be considered while calculating the stresses / applying design checks for rotation & movement ability of the Bearing.

5.4 Design verification for Curved sliding surfaces

When dimensioning sliding surfaces, the resultant of the co-existing active and induced horizontal forces generated due to sliding friction shall be considered.

5.4.1 Restraining Rings

The capacity of the Bearings which restraint only by curved sliding surface (refer figure 1) shall be checked for stability & separation against the Horizontal forces.

The capacity of the curved sliding surface for resisting the applied horizontal forces shall be checked by the following expression:

\[
H_u \leq \pi \times r^2 \times \sigma_{ss} \times \sin^2 (\theta - \beta - \alpha) \times \sin \beta
\]

in which

\[
\beta = \tan^{-1}\left(\frac{V_s}{N_s}\right)
\]

\[
\theta = \sin^{-1}\left(\frac{L}{2r}\right)
\]

where

\(V_s\)  factored Horizontal Load
\(L\)  projected diameter of the Sliding Surface perpendicular to the rotation axis
\(N_s\)  vertical Load due to Permanent Load effects
\(r\)  radius of the curved sliding surface
\(\beta\)  angle between the vertical and the resultant applied load
\(\alpha\)  design rotation angle
\(\theta\)  subtended semi-angle of the curved sliding surface
\(\sigma_{ss}\)  maximum average contact stress permitted on the sliding surface i.e.

\[
\sigma_{ss} = \frac{f_k \times k}{\gamma_m}
\]

where,

\[
\gamma_m = 1.4
\]

\(f_k\) is the characteristic value of compressive strength according to Table 1 and 
\(k\) is the reduction factor as described in Clause 4.3

Although the capacity of the Bearings curved sliding surface if satisfies the check for stability &
separation against the Horizontal forces. It is recommended to fix the bearing by a steel restraining ring for additional safety against separation & sliding off under unforeseen conditions.

In case the curvature of the sliding surface is inadequate to resist the applied horizontal forces, the spherical bearing shall be fixed by a steel restraining ring as shown in figure 5.

![Figure 5 – Arrangement of Restraining Ring in Fixed Spherical Bearing (Typical)](image)

For design and verification of the steel restraining ring capacity to withstand the effect of applied horizontal forces, following design rules shall be followed:

5.4.1.1 Direct Tensile Stress, \((\sigma_{t,rr})\) in the Restraining Ring Cross Section shall satisfy:

\[
\frac{V_{xy,sd}}{2 \times t_w \times h} \leq \frac{fy}{\gamma_m} \quad \text{where} \quad \gamma_m = 1.0
\]

5.4.1.2 Shear Stress, \((\tau_{s,rr})\) at Restraining Ring & Base Interface shall satisfy:

\[
\frac{1.5 \times V_{xy,sd}}{D_i \times t_w} \leq \frac{fy}{\gamma_m} \quad \text{where} \quad \gamma_m = 1.732
\]

5.4.1.3 Bending Stress, \((\sigma_{b,rr})\) at Restraining Ring & Base Interface shall satisfy:

\[
\frac{1.5 \times V_{xy,sd} \times h f_l \times 6}{D_i \times t_w^2} \leq \frac{fy}{\gamma_m} \quad \text{where} \quad \gamma_m = 1.0
\]

5.4.1.4 Equivalent Shear & Bending Stress shall satisfy:

\[
\sqrt{(\sigma_b^2 + 3 \times \tau_s^2)} \leq \frac{fy}{\gamma_m} \quad \text{where} \quad \gamma_m = 1.0
\]

5.4.1.5 The interface of the bottom component with the restraining ring shall be provided in radius to uniformly transfer the Horizontal Forces with causing the edge concentration.

\[
V_{xy,sd} \leq \frac{15 \times R_{rr} \times D_i \times f_u^2}{E d \times \gamma_m^2} \quad \text{where} \quad \gamma_m = 1.0
\]

5.4.1.5 Effective width of the contact surface \((w_e)\) shall be calculated by the following expression
\[ w_e \geq 3.04 \times \sqrt{\frac{(V_{xy,sd} \times R_{rr})}{(E_d \times D_i)}} \]

also,
\[ w \geq w_e + (\max, \alpha_d \times D_i) \]

where,

- \( V_{xy,sd} \): Resultant acting Horizontal Force in N
- \( D_i \): Internal dia. of the Restraining Ring in mm
- \( t_w \): Thickness of the Restraining Ring in mm
- \( R_{rr} \): Radius of curvature of the contact surface with the Restraining Ring
- \( h_{f1} \): Distance between the point of force application and the Restraining Ring Base in mm
- \( h \): Depth of the Restraining Ring in mm
- \( E_d \): Modulus of Elasticity of Steel i.e. 210000.00 MPa
- \( f_y \): Specified min. yield strength of the steel material in MPa
- \( f_u \): Specified min. tensile strength of the steel material in MPa
- \( \gamma_m \): Partial factor of Safety

### 5.4.2 Compressive Stress Verification

The following conditions shall be verified under a fundamental combination of actions:

\[ N_{sd} \leq \frac{f_k \times A_r \times k}{\gamma_m} \]

where

- \( N_{sd} \): is the design axial force at ultimate limit state
- \( f_k \): is the characteristic value of compressive strength as per Table 1
- \( \gamma_m \): partial safety factor for materials. The recommended value of \( \gamma_m \) shall be taken as 1.4, unless stated otherwise
- \( k \): Reduction factor as described in Clause 4.3
- \( A_r \): reduced contact area of the sliding surface expressed by the expression, \( A_r = A \times \lambda \)
- \( A \): contact area for flat sliding surface or projected area of the curved sliding surface i.e. \( A = \pi L^2 / 4 \)
- \( \lambda \): is a coefficient worked out by the expression, \( \lambda = 1 - 0.75 \pi e_t / L \)

\* \( A_r \) is the reduced contact area of the sliding surface whose centroid is the point through which \( N_{sd} \) acts with the total eccentricity \( e_t \), which is caused by both mechanical and geometrical effects.

For the purpose of compressive stress verification, the curved sliding surface shall be replaced by its projection on a plane surface as shown in figure 6.

For equal distribution of Compressive Forces, \( r \geq 1.5 \times L \)
5.4.3 Eccentricities

Internal forces and moments acting on the curved sliding surface due to frictional resistance, externally applied horizontal loads and the rotated condition of the bearing shall be taken into account when determining the resulting total eccentricity $e_t$ of the axial force $N_S$.

The resulting total eccentricity, $e_t$ shall be the algebraic sum of the several eccentricities that may occur simultaneously in a cross-section under consideration.

Thus,

$$e_t = e_1 + e_2 + e_3 + e_4 \text{ (as applicable depending on the condition)}$$

The different eccentricities for working out the resulting total eccentricity shall be calculated as per the expressions below:

5.4.3.1 Curved sliding surfaces

In the presence of rotational movements at curved surfaces, an internal moment occurs due to the frictional resistance. Regardless of whether the bearing has one or two surfaces, the associated eccentricity $e_1$ is:

$$e_1 = \mu_{\text{max}} \cdot r$$

For bearings with sliding surface as given in Table 2, the coefficient of friction $\mu_{\text{max}}$, for verification of the bearing and the structure in which it is incorporated shall be calculated as per expression given below. These values shall not be applied in the presence of high dynamic actions which may occur for instance in seismic zones. The effects of friction shall not be used to relieve the effects of
externally applied horizontal loads.

a) Coefficient of friction for PTFE

For sliding elements combined with dimpled and lubricated PTFE sheets, the coefficient of friction \( \mu_{\text{max}} \) is determined as a function of the average pressure \( \sigma_{\text{PTFE}} [\text{MPa}] \), as follows:

\[
0.025 < \mu_{\text{max}} = \frac{1.2}{10 + \sigma_{\text{PTFE}}} < 0.08
\]

For guides the coefficient of friction shall be considered to be independent of contact pressure. The coefficient of friction \( \mu_{\text{max}} = 0.08 \) shall be used.

b) Coefficient of friction for UHMWPE

For sliding elements combined with dimpled and lubricated UHMWPE sheets, the coefficient of friction \( \mu_{\text{max}} \) is determined as a function of the average pressure \( \sigma_{\text{UHMWPE}} [\text{MPa}] \), as follows:

\[
0.020 < \mu_{\text{max}} = \frac{1.3}{15 + \sigma_{\text{UHMWPE}}} < 0.065
\]

For guides the coefficient of friction shall be considered to be independent of contact pressure. The coefficient of friction \( \mu_{\text{max}} = 0.07 \) shall be used.

For zones where the minimum effective bearing temperature doesn’t fall below – 5 °C, the coefficient of friction values both for PTFE and UHMWPE sliding material as worked out from the above expressions may be reduced by 30 %. However, this reduction shall only be applicable for primary (in horizontal plane) sliding surfaces and not for Guides.

5.4.3.2 Sliding surfaces with external guides and restraining rings

For the spherical bearings designed to resist horizontal forces through external guides or restraining rings, (refer figure 2 c & d) and not by the curvature of the sliding surface, rotational movements produces an eccentricity \( e_2 \) which shall only be considered in the designing of the adjacent structural members (i.e. pedestal, beam etc) and the anchoring devices:

\[
e_2 = \frac{V_s}{N_s} \cdot \mu_{\text{fr}} \cdot c
\]

where,

\( c \) distance (in plan) between the Interface resisting / transferring the horizontal force and the centre of the sliding surface.

For bearings with sliding surface in guides as per Table 2, the coefficient of friction \( \mu_{\text{fr}} \) shall be taken from Table 4 below:

**Table 4: Co-efficient of Friction (\( \mu_{\text{fr}} \)) for Secondary Sliding Surfaces**

<table>
<thead>
<tr>
<th>Sliding Interface</th>
<th>(( \mu_{\text{fr}} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS – PTFE / UHMWPE</td>
<td>0.10</td>
</tr>
<tr>
<td>SS – Composite Material (CM1 / CM2)</td>
<td>0.20</td>
</tr>
</tbody>
</table>
5.4.3.3 Rotation

In all the types of bearings with two sliding surfaces a rotation angle, $\alpha$ produces an eccentricity $e_3$ of the vertical load on the curved surface which is:

$$e_3 = \alpha \cdot (r + b)$$

where,

$b$ distance (in elevation) between the cross-section under consideration and the sliding surface (Refer figure 6).

At any rate, this eccentricity acts nonetheless in the opposite direction.

In the type of bearings equipped with only one sliding surface, $e_3$ occurs only in the curved sliding surface and, furthermore, only when said sheet is attached to the convex backing plate.

5.4.3.4 Lateral forces

Lateral forces result from horizontal actions and the friction resistance of the other bearings in the structure. This eccentricity is not applicable for the curved sliding interface in the bearings where lateral forces are transmitted by external guides or restraining rings. In bearings of the fixed type with only one sliding surface or with internal / central guides, the horizontal load $V_s$ produces an eccentricity which is:

$$e_4 = \frac{V_s}{N_s} \cdot (r + b)$$

In all cases where the lines of application of lateral action and reaction are not coincident the resulting couple causes an eccentricity that shall be additionally taken into account.

5.4.4 Separation of Sliding Surface

With the exception of guides, it shall be verified that $\sigma_{PFE} \leq \sigma_{UHMWPE} \geq 0$ under the characteristic combination of actions. The condition $\sigma_p \geq 0$ is satisfied when the total eccentricity $e_t$ falls within the kernel of the projected area.

For circular sheets this condition is satisfied when:

$$e_t \leq \frac{L}{8}$$

where,

$L$ projected diameter (refer figure 6)

5.5 Guides

In the design of the Bearings where, externally applied horizontal forces are to be resisted, Guides either externally attached & projecting from the top sliding plate or internally located projecting from the piston & sliding inside the recess in the top sliding plate shall be used. The sliding interface shall
be fixed on to the Guides & its adjacent surface for low friction sliding movement. While the Stainless steel strips shall be affixed by continuous fillet weld, the sliding surface strips shall be either bonded with confinement or screwed to assist assembling. Composite materials shall be attached by bonding supplemented by mechanical attachment outside the sliding surface

In order to facilitate higher rotation freely, the sliding surface at Guides shall be placed into a rocker strip backside of which shall be curved to provide smooth full surface contact at the sliding interface even under rotation condition. Refer figure 7 for details.

![Figure 7 – Arrangement of Rocker Strip (Secondary sliding surface) in Guided Spherical Bearing (Typical)](image)

The following conditions shall be verified while designing the Guides for a Guided Bearing:

5.5.1 Radius of Curvature for the Rocker Strip shall satisfy:

\[ V_{y,sd} \leq \frac{23 \times R_{rs} \times L_{c} \times f_u^2}{Ed \times \gamma_m^2} \]

where \( \gamma_m = 1.0 \)

5.5.2 PTFE / UHMWPE Strip dimension shall satisfy:

\[ V_{y,sd} \leq \frac{L_s \times B_s \times k \times f_k}{\gamma_m} \]

where \( \gamma_m = 1.4 \)

5.5.3 Bending Stress, \( (\sigma_{b,gb}) \) in the Guide Bar shall satisfy:

\[ \frac{V_{y,sd} \times hf_2 \times 6}{L_x \times B_x^2} \leq \frac{f_y}{\gamma_m} \]

where \( \gamma_m = 1.0 \)

5.5.4 Shear Stress, \( (\tau_{s,gb}) \) in the Guide Bar shall satisfy:

\[ \frac{V_{y,sd}}{L_x \times B_x} + \sigma_{1,gb} \leq \frac{f_y}{\gamma_m} \]

where \( \gamma_m = 1.0 \)

5.5.5 Equivalent Stress, \( (\sigma_{v,gb}) \) in the Guide Bar shall satisfy:

\[ \sqrt{(\sigma_{1,gb}^2 + \tau_{s,gb}^2)} \leq \frac{f_y}{\gamma_m} \]

where \( \gamma_m = 1.0 \)
5.5.6 Clearance ‘c’ between sliding components in unused condition shall meet the following criterion:

\[ c \leq 1.0 \text{ mm} + \frac{L}{1000} \]

where,

- \( V_{y,sd} \) Acting transverse horizontal force in N
- \( R_{rs} \) Radius of curvature of the Rocker Strip contact surface with the bottom component in mm
- \( L_r \) Length of Rocker Strip in mm
- \( L_s \) Length of PTFE / UHMWPE Strip in mm
- \( B_s \) Width of PTFE / UHMWPE Strip in mm
- \( L_x \) Length of Guide Bar in mm
- \( B_x \) Width of Guide Bar in mm
- \( h_{f2} \) Distance between the point of force application and the Guide Bar interface with parent component in mm
- \( E_d \) Modulus of Elasticity of Steel i.e. 210000.00 MPa
- \( f_y \) Specified min. yield strength of the steel material in MPa
- \( f_u \) Specified min. tensile strength of the steel material in MPa
- \( f_k \) Characteristic value of compressive strength according to Table 1
- \( k \) Reduction factor as described in Clause 4.3
- \( \gamma_m \) Partial factor of Safety

5.6 Design verification of backing plates

The flat sliding surface and its mating (SS) shall be supported by metal backing plates with curved and flat surfaces respectively. In order to avoid unacceptably small clearance due to deformation under loads & stresses between the sliding and its mating surface, which could otherwise cease the Bearing rotation ability causing higher wear, the clearance between the adjacent backing plates shall be checked.

However, in Spherical and Cylindrical Bearings, the flat sliding surface is confined / mounted on a thick convex backing plate which apparently has high stiffness & rigidity against deformations. Thus only the deformation of the mating surface backing plate, \( \Delta w \) shall be calculated as per expression given in Annexure – D, Clause D.2 and shall satisfy the condition given in Clause D.1

6.0 Manufacturing

6.1 Curved Backing Plate

a) Dimensional Limitation & Tolerance

The thickness \( t_{b, min} \) of the curved backing plate housing the concave sliding surface shall be 16 mm and the space available on sides shall be min. 20 mm on radius (refer figure 8 below)
b) Recess in the backing plate for confinement of the Sliding Surface

The shoulders of the recess shall be sharp and square to restrict the flow of the sliding surface and
the radius at the root of the recess shall not exceed 1 mm (refer figure 9 below).

Key
1 Sharp edge

Figure 9 - Details of recess for Sliding Surface

The sliding surface shall ideally fit in the recess without clearance. The maximum permissible
tolerance on the fit of sliding surface inside the recess shall not exceed the values specified in Table
5.

Table 5 - Tolerance on Fit of sliding surface in the recess

<table>
<thead>
<tr>
<th>Dimension L (mm)</th>
<th>Gap (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 - 500</td>
<td>0.5</td>
</tr>
<tr>
<td>501 - 1000</td>
<td>1.0</td>
</tr>
<tr>
<td>1001 - 1500</td>
<td>1.5</td>
</tr>
</tbody>
</table>

L projected diameter (refer figure 6)

c) Flatness

Surface of the curved backing plate to receive the concave sliding surface shall be finished in such a
way that the maximum deviation $\Delta z$ from theoretical plane surface shall not exceed 0.0003·d or 0.2
mm, whichever is greater.
6.2  Concave Sliding Surface

The thickness \( t_p \) of the sliding surface and its protrusion ‘h’ in the unloaded condition with corrosion protection shall meet the conditions given in Table 6

### Table 6 - Thickness \( t_p \) and protrusion h of the Sliding surface

<table>
<thead>
<tr>
<th>Design values</th>
<th>Flat and curved sliding surfaces</th>
<th>Guides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness ( t_p ) in mm</td>
<td>( 2.25 \cdot h &lt; t_{PTFE} &lt; 8.0; ) with ( h ) in mm</td>
<td>( 5.0 &lt; t_{PTFE} &lt; 8.0 )</td>
</tr>
</tbody>
</table>
| Protrusion \( h \) in mm | \( h = 2.00 + \frac{L}{1500} \)  
\( L \) diameter of the projected area of the sliding surface in mm | \( h = 2.0 \pm 0.2 \) |

The tolerance on the protrusion \( h \) is \( \pm 0.2 \) mm for \( L \) less than or equal to 750 mm and \( \pm 0.3 \) mm for \( L \) greater than 750 mm. The protrusion \( h \) shall be verified at least three marked measuring points spread circumferentially, where the corrosion protection coating shall not exceed 200 \( \mu m \). The admissible tolerance on thickness of single sheet or associated multiple sheets of the sliding surface is \( +0.3, -0.0 \) mm for sheets with a diameter \( L \) less than 750 mm and \( +0.5, -0.0 \) mm for larger sheets.

Curved sliding surface sheets shall be circular and may be subdivided into a disc and an annulus. The disc, if subdivided, shall not be less than 750 mm in diameter and the width of the annulus shall not be less than 50 mm. The annulus may be sub-divided into max. four equal segments. Both the disc and the annulus may be retained in recesses. The separating ring of the backing plate shall not be more than 10 mm wide. Figure 10 shows the configurations of curved sliding surface sheets for spherical sliding surfaces.

Dimensions in millimeters

![Figure 10 - Subdivision of recessed Sliding Surface sheets for spherical sliding surfaces](image)

6.3  Sliding surface for guides

Dimension "a" shall not be less than 20 mm and the modified shape factor shall be greater than 4 (see figure 11).

\[
S = \frac{A_{\text{pp}}}{u \cdot h} \cdot \frac{t_p - h}{h}
\]
A_p is the compressed (undeformed) surface and u the perimeter of the Sliding Surface sheet.

Dimensions in millimeters

![Figure 11 - Examples of recessed sliding surface sheets for guides](image)

### 6.4 Hard Chromium Surface

The hard chromium surface shall be visually inspected for cracks and pores. In addition to the visual inspection, the absence of defects shall be verified by any suitable non-destructive test e.g. Ferroxyl Test in accordance with Annexure – E “Ferroxyl Test for Hard Chromium Plating” of this specification. If any defects in the small portion are detected in the test, the hard chrome plating shall be reworked and the test shall be applied on the entire chrome plated surface and if the defects are still noticed, the hard chrome plating shall be rejected.

Since hard chromium plating is not resistant to chlorides in acid solution or to fluorines and can be damaged by air borne particles, such as occur in industrial environment, special provision shall be made to protect the surfaces in those conditions.

### 6.5 Protection against corrosion and contamination

While doing the corrosion protection as specified in clause 4.10 of this specification. Following care shall be taken:

Where the austenitic steel sheet is attached to it’s backing plate by continuous fillet weld, the area of the backing plate covered by the austenitic steel sheet, after shot blasting, shall be provided with two coats of epoxy primer (dry film thickness 50 µm to 100 µm), if not stated otherwise.

Where the austenitic steel sheet is attached by screwing, counterpunched screwing or riveting the full corrosion protection system shall be applied to the backing plate behind the austenitic steel sheet.

Provision against contamination of the sliding surface shall be made by suitable devices e.g. wiper seal, rubber apron or bellows. Such protection devices shall be easily removable for replacement and / or maintenance inspection purpose.

### 6.6 Assembly

Prior to assembly the sliding surfaces shall be cleaned.

After cleaning and prior to assembly, the dimpled sliding surface shall be lubricated with lubricant according to Clause 4.8 in a way ensuring that all the dimples are filled without air entrapment. For guides the sliding material shall be initially lubricated by rubbing a small amount of lubricant into the surface and wiping off the remainder.
During assembly process, precautions shall be taken against contamination of lubricated surfaces.

The bearing may be provided with a movement indicator scale which is to be fixed on the side face of the top sliding plate with a pointer pointing to it from the Bearing bottom component.

### 7.0 Acceptance, Certification and Marking

Stipulations of this clause regarding the Acceptance Testing, Certification and Marking shall be strictly adhered which forming the basis of Product conformance and acceptance for the Spherical & Cylindrical Bearings.

### 7.1 System of attestation and conformity

Following will form the basis of acceptance of the Spherical & Cylindrical Bearings:

(a) Tasks of the manufacturer:
   1. Raw Material Acceptance / Testing
   2. Factory production control / in-process testing
   3. In-house Test on Finished Bearing

(b) Tasks of the accepting / inspection authority:
   1. Initial inspection of factory and of factory production control
   2. Continuous surveillance on process of production and conformance test on raw materials & production in-process
   3. Witness of final acceptance testing of finished product.

#### 7.1.1 Manufacturer Internal Testing

Apart from the raw material and in-process inspection to be carried out & documented for all Bearings and their components. The Bearings thus manufactured shall be subjected to rigorous in house testing by the manufacturer prior to offering for the acceptance testing. Following in-house / internal testing on the finished Bearings shall be performed by the manufacturer:

i) All Bearings shall be checked for surface finish or any other discernible superficial defects.

ii) All the bearings shall be checked for overall dimensions as per the manufacturing tolerances specified in this guideline and the relevant contract specifications.

iii) All Bearings of the entire production quantity to be offered for acceptance shall be load tested to 1.10 times the maximum design vertical load in serviceability condition as shown in the drawings.

iv) From the entire production quantity to be offered for acceptance, One Bearing each selected at random shall be tested for Rotation (design rotation or 0.015 radians whichever higher), Co-efficient of Friction (at permanent and maximum Vertical Loads separately) and Combined Vertical & Horizontal Load test (at 1.10 times the maximum serviceability design loads), as the case applicable.

**NOTE:-**
- For tests specified under iii) & iv) of Clause 7.1.1 except for co-efficient of Friction test, the Bearings shall be held under Test Load for a period of 30 minutes.
- All testing shall be done for SLS Loading.
7.1.2 Acceptance Test by Inspecting Authority

Bearings passing the in house test requirements are then offered to the accepting / inspection authority for Acceptance Testing. Following Acceptance tests in presence of the Inspection authority shall be performed on the components of the bearings or the bearing as a whole, as applicable.

a) Tests for conformance of raw materials & its processing

i) In addition to the certificates of Raw materials from the supplier / manufacturer forming the initial basis of acceptance. Random sampling & testing at Independent NABL accredited lab for the material used in the production of the Bearings like steel, sliding surface, stainless steel, Bolts etc. shall be done. The inspection / accepting authority at his discretion shall relax and not insist on conducting the above test subject to availability of the satisfactory test data for the similar test conducted on materials of bearings recently manufactured & supplied for other projects within a period of six months preceding the date of Testing.

ii) Ultrasonic inspection of the steel components

iii) Test on welding e. g. Dye Penetration Test

iv) Test on hard chromium plating e. g. Ferroxyl Test

v) Hardness test for the Mating Surface

vi) Surface finish of the stainless steel sheet

vii) Thickness of the anti-corrosive treatment etc.

b) Acceptance Test on finished Bearings

i) Bearings shall be randomly checked for surface finish or any other discernible superficial defects.

ii) Bearings shall be randomly checked for overall dimensions as per the Manufacturing tolerances specified in this guideline and the relevant contract specifications.

iii) One Bearing selected at random from the lot under acceptance shall be load tested to 1.25 times the maximum design vertical load in serviceability condition as shown in the drawings.

iv) One Bearings selected at random from the lot under acceptance shall be tested for design rotation or 0.015 radians whichever is higher at corresponding Vertical Load of 0.75 times the maximum design serviceability vertical load as shown in the drawings. Additional pre-fabricated taper plates inducing the desired rotation into the Bearing shall be used in the Test assembly for the above test.

v) For movable Bearings (Free Float and Slide Guide Types), One Bearing selected at random per lot shall be tested in order to determine the co-efficient of friction at permanent and maximum Vertical Loads in serviceability condition separately, the value of friction shall not exceed 0.03 under lubricated condition.

vi) For Bearings required to resist horizontal forces (Fixed and Slide Guide Types), One Bearing selected at random from each lot shall be subjected to combined Vertical and Horizontal Load Test to 1.10 times of the respective maximum design loads and forces in serviceability condition.
NOTE:-

- For tests specified under iii), iv) & vi) of Clause 7.1.2, the Bearings shall be held under Load for a period of 30 minutes.
- All testing shall be done for SLS Loading.

For the purpose of Lot classification, following definitions shall be applicable

- A lot shall comprise of the total number of Bearings manufactured together, of the type & load capacity as defined below, and offered for the Inspection at a time to the Inspecting / Accepting authority. However, the maximum number of Bearings in one lot shall be limited to 24. Bearings in excess of 24 Nos. shall be treated as separate lot.
- The fixed & movable Bearings shall be classified as separate Lots. However, the movable bearings irrespective of uni-directional & bi-directional movement abilities shall be placed under the same lot.
- In terms of Load capacity, Bearings with max. design vertical load less than 500 MT shall be considered as one lot and Bearings with more than 500 MT vertical load capacity shall be considered as separate lot.

7.2 Observation

During the Testing, the inspecting / accepting authority shall examine the behavior of the Bearings for any signs of Deformation, Crack on the Sliding surface and / or mating surface, Separation / Lift off between the sliding interface or ceasing of the Bearing Components. After the above Tests are completed, the tested bearings shall be removed from the test machine, dismantled and the components shall be examined for any signs of distress, permanent deformation in the components especially the sliding surface, warping, scoring, cracks or other permanent defects which may affect the serviceability or durability of the bearing.

The inspecting / acceptance authority apart from witnessing the above test on finished Bearings shall also inspect the documents and reports submitted by the manufacturer about the internal factory production control i. e. raw material, in-process production and internal testing of finished product carried out by the manufacturer.

7.3 Inspection Certificate

The details of the tests & inspection carried out both in house and in the presence of the Witnessing authority shall be recorded in the standard testing formats along with their observations. These filled up formats along-with the raw material test certificates, reports of the tests done in-process e. g. welding (DPT), hard chromium plating (Ferroxyl Test), mating surface hardness test, ultrasonic test, S/S surface finish and Paint DFT etc. shall be compiled and submitted to the Inspecting / Acceptance Authority as Test Reports.

7.4 Certification

The approving / accepting agency after getting satisfied with the Quality of the Product manufactured shall issue Certificate of conformity of the product stating the conformity with the provisions of this Specification and clearance to the Manufacturer to effect the shipment of the Bearings to the Job Site.
7.5 Marking

All Bearings shall have suitable identification plates permanently affixed which shall be visible after installation, identifying the following information:

- Name of Manufacturer
- Month & Last two digits of the year in which the Bearing Manufactured (mm/yy)
- Serial Number of the Bearing
- Bearing Designation & Type
- Design Performance parameters viz. Load, Movement etc.

Besides this, the Bearing Top Surface shall also be marked with the following information to facilitate their correct installation at site

- Centerline Marking
- Bearing Designation & Type
- Orientation Marking to facilitate correct placement on the Pedestal
- Direction of Major and Minor movement, as appropriate
- Preset Marking, if applicable.

8.0 Packaging, transport and storage

The bearing shall be labeled by the manufacturer with the marking requirement as stated in Clause 7.5. The marking shall only be applied when the prerequisites, regarding manufacturing, testing & acceptance in accordance with Clauses 6 & 7 are fulfilled in all respect.

Bearings being made up of several components, which are not rigidly fixed together, shall be temporarily clamped together at the place of manufacture. Such clamps shall be sufficiently strong to hold the various bearing components in their correct positions during handling & transportation. They shall be marked / painted with a clear distinguish colour from that of the Bearing paint for easy identification. The Transportation Bracket shall be easily removable after installation or designed to break once the bearing starts to function, without damaging the bearing.

All bearings that are too heavy to be handled manually shall have provision for the lifting devices.

Bearings shall be wrapped under heavy duty polythene sheets and secured on wooden pallets or inside Boxes strong enough to withstand the handling & transportation. Bearings shall then be transported to the Job site under secured & horizontal condition.

The Bearings at the Job site shall be placed horizontally above the Ground Level on wooden pallets under covered space to avoid spoilage by rain water & dust etc.

9.0 Aspects Related to Bearing Installation & Performance

In order to ensure bearing alignment & placement in accordance with the Contract plan & specifications, a reference index marking shall be provided on the Bearings Bottom & Top Component.

The deviation in level & alignment both in plan & elevation, in installation of Bearings from the
standard location, shall not exceed 3% of the Bearing shorter dimension in plan and of the Bearing Total Height in elevation.

The deviation in parallelism of the Sliding surface with respect to datum shall not exceed 1% of the Length in the direction of measurement.

9.1 Installation

Bearings are to be installed with due care to ensure their correct functioning in accordance with the design of the Structure. The primary factors to be considered during the Installation of the Bearings are:

Design Based Aspects

- Provision of the Bearings in the structure shall be so made so as to have the least chances of dust & dirt accumulation and also spoilage from rain water seepage that may affect their performance.
- Provision of Jacking Points shall be made during the design / construction of the Structure.
- Consultation with the Bearing manufacture shall be done at an early stage of the Bridge design to avoid the hassles of Tandons / Prestressing Strands fouling with the Bearing Dowels.

Transportation & Site Handling Aspects

- Transport Brackets are not to be relied for the Lifting of the Bearings.
- Upon receipt of the Bearings at Site, the contractor shall have a visual Examination of the Bearings to ensure that no damage or Displacement of the Bearing Components is taken place during the Transportation. Any rectification or re-assembly if required shall be done strictly in the presence of the Manufacturer’s Representative.

Installation Aspects

- Bearings shall be installed truly horizontal with Top & Bottom Components of the Bearings perfectly parallel to each other, unless otherwise stated.
- For pre-cast construction, the positioning of the Bolts & Dowels embedded in the Substructure / Superstructure shall be made strictly as per the Shop Drawings.
- The Dowels / Distribution Plates shall be properly grouted with suitable grout material ensuring no voids, honeycombing underneath & above the Bearing bottom & top Plates respectively. In case of Movable Bearings, particular care shall be taken to ensure the correct Orientation of the Bearings.
- For In-situ type of Construction the Bearings shall be covered from all sides to avoid the ingress of cement slurry etc. inside the bearing Components.
- In case of Pre-cast Construction, extreme care is to be taken to avoid impact loading onto the Bearings while launching the Girders / Superstructure. Girders shall not be rested freely over the Bearings without any Support.
- Transport Brackets shall be removed at an appropriate time after the casting of the cross diaphragm and setting of the Superstructure Concrete.
- Bearings and its components shall be checked for any dust, dirt or Cement Slurry Deposit etc. and the surrounding area shall be cleaned thoroughly once the Process of bearing Installation is finished.
9.2 Maintenance

Bearings shall be designed and manufactured to make them virtually maintenance free so that the undesirable effects caused by extreme atmosphere or aggressive environmental condition / unforeseen events can be eliminated to a great extent. However, the surrounding area of the bearings shall always be kept clean and dry to avoid damage to the Bearings.

Provisions for suitable easy access to the bearing shall be made in the construction drawings for the purpose of inspection and maintenance. Provision shall be made for jacking up the superstructure so as to allow repair / replacement of the bearings, if required at any time in future.

Inspection of Bearing at site is required to be carried out from time to time to ascertain the performance of the Bearings. Periodic nominal maintenance of bearing shall be carried out in order to ensure better performance and longer life of the Bearings. The Bearings are generally required to be inspected at an interval of approx. one year for the first five years and at an interval of two years thereafter or as agreed between the client and the contractor. However, the bearings shall also be examined carefully after unusual occurrences, like heavy traffic, earthquakes, cyclones and battering from debris in high floods.

The inspection shall be preceded by careful cleaning of the Bearings as well as its surrounding space, depending on the actual conditions around the Bearings, e.g. deposit of salt, debris, dust or other foreign material.

Elements of Inspection

The following are recommended inspection elements and actions which are considered necessary to monitor and upkeep the bearings:

1) Measurement of Movement: During inspection at site, measurements are required to be taken and documented to compute its movement and rotation values in relation to their design values to ascertain whether the performance of the bearings are satisfactory. To ascertain maximum movement, measurement should be taken once during peak winter (early morning) and once during peak summer (afternoon) and corresponding atmospheric temperature should be recorded. The recorded value of movement shall be compared with the design values.

2) Measurement of Dimensions: Overall dimensions of the Bearings are required to be measured and compared with the actual dimensions to ascertain any excessive stress or strain on the Bearing.

3) Evidence of locked in Condition: If any movable or rotating part of a Bearing is found to be in locked - in / jammed condition, necessary rectification measures shall be taken immediately.

4) Evidence of Corrosion: If corrosion of any part of exterior exposed steel surface of the bearing is detected, the following measures may be taken. In addition, the root cause of defect should be searched and proper actions should be taken to avoid recurrence of the problem.
   - Detect affect part.
   - Wire brush the affected portion to clean of it’s rust.
   - Apply protective coating as per Manufacturer’s Specifications.

5) Condition of the adjacent Bridge Structure: The adjacent structure of the Bearings are also required to be inspected for any damage and necessary actions to repair the same, should be taken immediately.
Results and Actions

The results of every inspection has to be recorded in the inspection report and shall be deeply discussed with the project Consultants and the Bearing Manufacturer and classified in different categories depending upon the action required to be taken like:

(1) Re-inspection and/or monitoring is required.

(2) Further measurements/long-term monitoring or design analysis needed (e.g. considering extreme temperatures/exposures, variation of loads, etc.).

(3) Minor repair works e.g. cleaning, repainting, etc.

(4) Repair or replacement of entire bearings or parts of the Bearings.

In case of defects where the cause of necessary actions cannot be determined by the inspecting person or the responsible Bridge Engineer, the bearing manufacturer shall be consulted.
ANNEXURE – A

A.0 Low Friction Thermo-plastic Sliding Material (PTFE or UHMWPE)

A.1 Pattern of Dimples

Fully molded sheets with cavities or dimples for lubrication shall be used for flat / curved sliding surfaces. The dimples shall be formed by hot pressing or molding and strictly not by machining or drilling. Where dimples are produced by hot pressing, the temperature during the pressing process shall not exceed 200°C. The pattern of dimples shall be as shown in figure A.1.

Dimension in Millimeters

Key

1 main direction of sliding

Figure A.1- Pattern of dimples in recessed PTFE / UHMWPE sheet

A.2 Material Properties

The raw material for PTFE or UHMWPE shall be conforming to the properties listed in Table A.2.

Table A.2 - Mechanical and Physical Properties of PTFE & UHMWPE

<table>
<thead>
<tr>
<th>Property</th>
<th>Testing Standard</th>
<th>Requirement</th>
<th>Unit of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PTFE</td>
<td>UHMWPE</td>
</tr>
<tr>
<td>mass density</td>
<td>EN ISO 1183 (all parts)</td>
<td>2140 - 2200</td>
<td>930 ± 20%</td>
</tr>
<tr>
<td>tensile strength</td>
<td>EN ISO 527 -1 and -3</td>
<td>≥ 24</td>
<td>≥ 30</td>
</tr>
<tr>
<td>elongation at break</td>
<td>EN ISO 527-1 and -3</td>
<td>≥ 300</td>
<td>≥ 250</td>
</tr>
<tr>
<td>ball hardness</td>
<td>EN ISO 2039-1</td>
<td>23 - 33</td>
<td>33 ± 20%</td>
</tr>
</tbody>
</table>
A.3  Test Requirements

The test specimens shall be prepared from fully finished sheet but without impressed dimples. They shall be tested at 23°C ± 2°C. Mass density shall be determined on three specimens.

Tensile strength test and elongation at break shall be conducted on five specimens. The thickness of the specimens shall be 2 mm ± 0.2 mm and the speed of testing shall be 50 mm / min.

A total of 10 ball hardness tests shall be conducted using at least three specimens with a minimum of three tests per specimen; the thickness of the specimens shall be at least 4.5 mm.

All specimen shall pass all the tests conducted on them. In case a specimen representing a particular lot fails to pass the test, the entire lot shall stand rejected.

The admissible tolerance on thickness of single PTFE / UHMWPE sheets or associated multiple sheets is 0 +0.3 mm for sheets with a diameter L less than 1200 mm and 0+0.4 mm for larger sheets.
ANNEXURE – B

B.0 Composite Materials for Secondary Sliding Surfaces (Guides)

B.1 Composite Material CM1

This is a composite material consisting of three layers; a bronze backing strip and a sintered interlocking porous matrix, impregnated and overlaid with a PTFE / lead mixture.

The material shall conform to the characteristics listed in Table B.1. In addition, the condition of the material and its surface finish shall be checked visually.

**Table B.1- Characteristics of CM1**

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition by mass</th>
<th>Thickness</th>
<th>Hardness HB - EN ISO 6506 (all parts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze backing</td>
<td>CuSn 6</td>
<td>5 to 7.50 %</td>
<td>80 to 160</td>
</tr>
<tr>
<td>Bronze interlayer</td>
<td>CuSn 10</td>
<td>10 to 12%</td>
<td></td>
</tr>
<tr>
<td>Composite material</td>
<td>PTFE + Pb</td>
<td>49% to 62%</td>
<td></td>
</tr>
</tbody>
</table>

**Bronze backing**

- **Material**: CuSn 6
- **Composition by mass**:
  - Sn: 5 to 7.50%
  - P: ≤ 0.35%
  - Pb: ≤ 0.10%
  - Fe: ≤ 0.10%
  - Zn + Ni: ≤ 0.50%
  - Others: ≤ 0.30%
  - Remainder Cu: (2.1 ± 0.15)%
- **Thickness**: 15.0 ± 0.025 mm
- **Hardness HB - EN ISO 6506 (all parts)**: 80 to 160

**Bronze interlayer**

- **Material**: CuSn 10
- **Composition by mass**:
  - Sn: 10 to 12%
  - Pb: ≤ 1.00%
  - P: 0.25 to 0.4%
  - Si: ≤ 0.17%
  - Fe: ≤ 0.15%
  - Ni: ≤ 0.15%
  - Others: ≤ 0.50%
- **Saturation with PTFE - Pb**: ≥ 25%
- **Thickness**: 0.25 ± 0.15 mm

**Composite material surface layer**

- **Material**: PTFE + Pb
- **Composition by mass**:
  - Pb: 49% to 62%
  - Remainder PTFE
- ** Thickness**: 0.01 ± 0.02 mm
- **Total thickness**: 2.48 ± 0.015 mm
- **Overlay adhesion – EN ISO 2409**: minimum GT2
B.2 Composite Material CM2

The material shall consist of a flexible metal mesh which is sintered into a PTFE compound with the bearing or sliding surface having the thicker PTFE coat.

The metal mesh shall be CuSn6 stabilized mesh from 0.25 mm diameter wires which are linked at intersections and which has a thickness after calendaring of approximately 0.4 mm. The mesh count in warp and weft direction shall be $16 \pm 1$ per 10 mm.

The PTFE compound shall be PTFE with $30\% \pm 2\%$ filler content, consisting of glass fibers and graphite.

The material is to conform to the characteristics listed in Table B.2. In addition, the condition of the material and its surface finish shall be checked visually.

<table>
<thead>
<tr>
<th>Table B.2- Characteristic of CM2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
</tr>
<tr>
<td><strong>Tensile Strength</strong></td>
</tr>
<tr>
<td><strong>Elongation</strong></td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
</tr>
<tr>
<td><strong>Overlay adhesion</strong></td>
</tr>
</tbody>
</table>
### ANNEXURE – C

**Bridge Bearing Design Questionnaire Form**

<table>
<thead>
<tr>
<th>Project / Structure Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Identification Mark / Number</td>
<td></td>
</tr>
<tr>
<td>Qty. required for each type</td>
<td></td>
</tr>
<tr>
<td>Seating Material</td>
<td>Upper Surface</td>
</tr>
<tr>
<td>Allowable* Contact Pressure (N/mm²)</td>
<td>Upper Surface</td>
</tr>
<tr>
<td></td>
<td>Lower Surface</td>
</tr>
<tr>
<td>Design Load (MT)</td>
<td>Serviceability (Normal Condition)</td>
</tr>
<tr>
<td></td>
<td>Serviceability (Seismic Condition)</td>
</tr>
<tr>
<td></td>
<td>Ultimate Limit state</td>
</tr>
<tr>
<td>Translation (mm)</td>
<td>Serviceability Limit state</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ultimate Limit state</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whether Pre-setting allowed (A) / Not-allowed (NA)</td>
</tr>
<tr>
<td>Rotation (Rad)</td>
<td>Serviceability Limit state</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum available Structure Dimensions for Dispersion</td>
<td>Upper surface</td>
</tr>
<tr>
<td></td>
<td>Lower surface</td>
</tr>
<tr>
<td>Overall Height Clearance (Pedestal + Brg.)</td>
<td></td>
</tr>
</tbody>
</table>

contd…….
<table>
<thead>
<tr>
<th>Bearing Dimensions Restrictions (If any)</th>
<th>Upper surface</th>
<th>Lower surface</th>
<th>Overall Height</th>
<th>Type of fixing required (Eg. Dowels / Distribution Plate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Longitudinal</td>
<td>Longitudinal</td>
<td></td>
<td>Upper face</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>Transverse</td>
<td></td>
<td>Lower face</td>
</tr>
</tbody>
</table>

* In case the allowable concrete pressure is not determined or known, then the grade of Concrete / steel / other material shall be specified for both the Upper & Lower Surface.

* Attach separate sheets to state additional requirements viz. Bearing Material, pre determined pedestal size (if available), cement mortar, epoxy, in situ concrete, precast concrete, steel etc.

* The Bearing Schedule should accompany General Arrangement Drawings showing Typical Support Plan Details, Layout of Structure with schematic arrangement of Bearings on Support, Sub & Superstructure details adjoining Bearing Location.
ANNEXURE – D

D.0 Deformations & Thicknesses of the Backing Plates

D.1 Permissible Deformation of the flat mating surface Backing Plate.

The deformations \( \Delta w \) as shown in figure D.1 below of the flat mating surface backing plate shall satisfy the following condition which could otherwise create, unacceptably small clearance between the adjacent backing plates and as a result, higher wear will occur.

\[
\Delta w \leq h \left( 0.45 - 2 \sqrt{\frac{h}{L}} \right)
\]

Where

\( L \) diameter of the Sliding Surface perpendicular to the rotation axis (mm)
\( h \) projection of the Sliding Surface above the recess (mm)

![Figure D.1 - Deformations of backing plates](image)

The stress in the backing plate induced by the respective deformation shall not exceed the elastic limit in order to avoid permanent deformations.

D.2 Actual Deformation of the flat mating surface Backing Plate.

The maximum relative deformation \( \Delta w \) in the backing plate over the diameter \( L \) shall be calculated from the following expression:

\[
\Delta w = \frac{0.55}{L} \cdot k_c \cdot \alpha_c \cdot k_b \cdot \alpha_b
\]

where,

\[
k_c = 1.1 + (1.7 - 0.85 \cdot \frac{d_b}{L}) \cdot (2 - \frac{d_b}{L_0}) \text{ if } L_0 \leq d_b \leq 2 \cdot L_0
\]

\[
k_c = 1.1 \text{ if } d_b > 2 \cdot L_0
\]

\[
\alpha_c = \frac{N_{Qd}}{E_c} + \frac{N_{Qd}}{E_{ce}}
\]

\[
k_b = 0.30 + 0.55 \cdot \frac{d_b}{L}
\]

\[
\alpha_b = \left[ \frac{L}{L + 2 \cdot t_b} \right]^2 \cdot \left[ 3 \cdot \frac{L_0}{d_b} \right]^{0.4}
\]
where,

\( d_b \) diameter of the backing plate or 1.13 \( a_b \) (\( a_b \) being the side of the square plate or the minor side of the rectangular plate)

\( t_b \) thickness of the backing plate; for backing plates with a concave surface the calculation may be based on the equivalent constant thickness \( t'_b \)

\[
t'_b = t_{b, \text{min}} + 0.6 \left( t_{b, \text{max}} - t_{b, \text{min}} \right)
\]

\( L \) diameter of sliding surface

\( L_0 \) reference diameter = 300 mm

\( N_{Qd} \) design axial force due to variable actions

\( N_{Gd} \) design axial force due to permanent actions

\( E_c \) short term static modulus of elasticity of concrete i.e. \( 5000 \sqrt{f_{ck}} \)

\( E_{ce} \) modulus of elasticity of concrete, for permanent load effects i.e. \( 0.5 E_c \)

The structural concrete members to which the backing plates are attached shall be of min. M35 Grade in accordance with IS: 456 or greater. Use of Mortar Layers between concrete & steel plate of equivalent or higher strength than concrete is also allowed. Similarly material for steel backing plates shall be steel grade having the yield strength as 280 MPa min.

The above also applies when using lower concrete strength classes and/or steel grades, provided the permissible deformation values as calculated above in D.1 are reduced by a factor of:

- 0.90 when using concrete grade less than M35 but limited to M30
- 0.67 when using steel having yield strength less than 280 MPa but limited to 230 MPa
- 0.60 when using both concrete grade less than M35 and steel with yield strength less than 280 MPa but both limited to minimum M30 Grade and 230 MPa respectively

D.3 Thickness of the Backing Plate for concave Sliding Surface

The thickness \( t_{b, \text{min}} \) of the backing plate for concave sliding surface i.e. Bearing Bottom Plate shall be:

\[
t_{b, \text{min}} > 0.025 \cdot \sqrt{a_b^2 + b_b^2}
\]

or 16 mm, whichever is greater

D.4 Thickness of the Backing Plate for flat mating Surface

The thickness \( t_b \) of the backing plate for flat mating (SS) surface i.e. Bearing Top Plate shall be:

\[
t_b > 0.040 \cdot \sqrt{a_b^2 + b_b^2}
\]

or 20 mm, whichever is greater, where:

\( a_b \) is the minor side of backing plate and \( b_b \) is the major side of backing plate.
ANNEXURE – E

E.0 Ferroxyl Test for Hard Chromium Plating

E.1 Purpose of the Test

The Test objective is to ascertain the soundness and integrity of the Hard Chromium Plating at the Curved mating surface.

E.2 Principle

The test method is based on the principle that cracks and porosity extending through the hard chromium layer to the steel substrate will be revealed as blue marks due to the reaction of Fe-II-ions with the indicator solution of potassium ferrocyanide III and sodium chloride.

E.3 Indicator Solution Composition

The ferroxyl indicator solution is composed of 10g K₃[Fe(CN)₆] and 30g NaCl in 1 l of distilled water or water completely desalinated by ion exchange.

Note: As skin contact with indicator solution shall be avoided, skin protection is required and food shall not be consumed while handling the indicator solution. The indicator solution in contact with acids releases extremely toxic prussic (hydrocyanic) acid.

E.4 Test Specimen & Preparation

The test shall be performed on min. 20% of the contact area of the surface.

The test shall be carried out at a temperature between 5°C and 40°C.

In order to prevent false indications, either the atmosphere in the vicinity of the test shall be free from ferrous particles or the test sample shall be covered and protected from dust and foreign material.

Immediately before the test, the hard chromium layer shall be cleaned with an acid-free degreasing agent.

E.5 Test Procedure

The hard chromium area to be tested shall be covered with white blotting paper impregnated with the indicator solution. The wet paper shall adhere firmly to the hard chromium surface without wrinkles or blisters.

The solution shall remain in contact with the surface for 1 hour min. At the end of the test period, before removing the blotting paper, it shall be identified and checked for changes in colour.

Defective areas in the hard chromium layer will be indicated as blue-coloured marks on the paper. After the test, the indicator solution shall be completely removed from the sample by means of water or alcohol and then the surface shall be dried.

E.6 Test Results and its Reporting

The test report shall include at least the following items:
a) Identification of the test pieces (name of manufacture, origin and number of manufacturing batch) and the unique serial number of the bearing, if applicable.

b) Condition of the test pieces prior to and after testing (visual damages).

c) Date, duration and temperature of test.

d) Test results (in case of damage, the recordings shall be enclosed with the test report).

e) Any operating procedures not described in this clause and any abnormal incidents occurring during the test.