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STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

SECTION: IX

BEARINGS
PART-III: POT, PIN, METALLIC GUIDE AND PLANE SLIDING BEARINGS

(First Revision)

INDIAN ROADS CONGRESS
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STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

SECTION: IX

BEARINGS
PART-III: POT, PIN, METALLIC GUIDE AND PLANE SLIDING BEARINGS

INTRODUCTION

The Standard Specifications and Code of Practice for Road Bridges, Section IX–POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings, Part-III based on working stress method was first published in March, 2002. Thereafter, unprecedented growth of knowledge in the field of Bridge Bearing Design, Manufacturing & Installation, Acceptance Specifications, Certification & Marketing and Development of high performance materials took place in the past 15 years. Hence, a need was felt by B-6 committee (2012-2014) to revise this document based on Ultimate Limit State (ULS) condition and to include Plain sliding bearing. The reconstituted B-6 Committee in 2015 assigned the task of preparing the initial revised draft to Shri S. Majumdar and Dr. M.V.B Rao. The revised draft "Standard Specifications and Code of Practice for Road Bridges, Section IX - Part III - POT, PIN, Metallic Guide and Plane Sliding Bearings" was circulated among the members of B-6 Committee for inviting comments from its Members. Members submitted their comments on the circulated draft document to B-6 Committee. The B-6 Committee constituted a Sub-Committee comprising of the following members to incorporate the comments in the revised draft document appropriately:

(i) Shri A.K. Banerjee, Convener;

(ii) Shri H.C. Arora;

(iii) Shri Alok Bhowmick;

(iv) Col. Ashok Bhasin;

(v) Dr. S.S. Gaharwar.

The Sub-committee finalized the revised draft document and submitted it to B-6 Committee. The B-6 Committee discussed and approved the document in its meeting held on 15th September, 2017 for placing it in the Bridges Specifications and Standards (BSS) Committee. The BSS Committee approved the document in its meeting held on 23rd October, 2017. Subsequently, the Executive Committee approved the document on 2nd November, 2017 for placing it before the IRC Council. Finally, the document was considered by the IRC Council in its meeting held on 3rd November, 2017 during the Annual Session held at Bengaluru (Karnataka) and was approved for publication.

The Bearings, Joints and Appurtenances Committee (B-6) of the Indian Roads Congress was constituted in 2015 with the following personnel:

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(Nirmal, S.K.)

1 SCOPE

This section of the specification (referred to as ‘code’ hereinafter) deals with requirements for the materials, design, manufacture, testing, installation and maintenance of Pot, Pin, Metallic Guide and Plane Sliding bearings for road bridges. The provisions of this code are meant to serve as a guide to both design and construction engineers, but mere compliance with the provisions stipulated herein will not relieve them in any way of their responsibility for the stability and soundness of the structure designed and erected.

This part of code specifies the requirements for the design and manufacture of pot bearings which will be used for operating temperatures between – 20 °C and 50 °C.

Pot bearings with confined elastomeric pressure pads up to 1500 mm diameter are within the scope of this code.

High performance elastomeric pressure pad in combination with specific internal seal and sliding material (e.g. UHMWPE) can be used subjected to availability of approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading international Specifications.

Bearings which are subjected to tensile loads are beyond the scope of this code.

Bearings which are subjected to rotations greater than 0.03 radians are beyond the scope of this code.

Sliding surfaces with a diameter of the circumscribing circle of single or multiple PTFE sheets or other approved sliding materials e.g. UHMWPE approved through ETA, FHWA or similar acceptance by other leading international Specifications, less than 75 mm or greater than 1500 mm, are outside the scope of this code. Sliding elements for use as temporary devices during construction, for example during launching of the superstructure, are also outside the scope of this code.

For demanding application in situations beyond the limitations stated above, specialist literatures and international codes shall be followed. In such situations, only specialist manufacturers, having proven experience of designing and supplying similar bearings in similar situations, shall be engaged.

2 TERMINOLOGY

2.1 Pot Bearing

A bearing consisting of a metal piston supported by a disc of unreinforced elastomer that is confined within a metal cylinder for allowing rotational movement about any axis in horizontal plane and to bear and transmit vertical load. Pot bearings may be provided with sliding assembly (with or without restraint in the form of guide along a desired direction to bear and transmit horizontal force) comprising of stainless steel plate attached to metal backing plate sliding in horizontal plane over sliding material confined in recess(s) on the piston which shall be termed as Sliding / Guided Pot bearings. Depending on the desired degree of freedom Pot bearings may be of three types as follows:

2.1.1 *Fixed Pot Bearing:*

A type of Pot bearing which along with vertical load, bears and transmits horizontal force in any direction and allows rotation about any axis in horizontal plane without permitting any movement in horizontal plane **(Fig. 2.1)**.

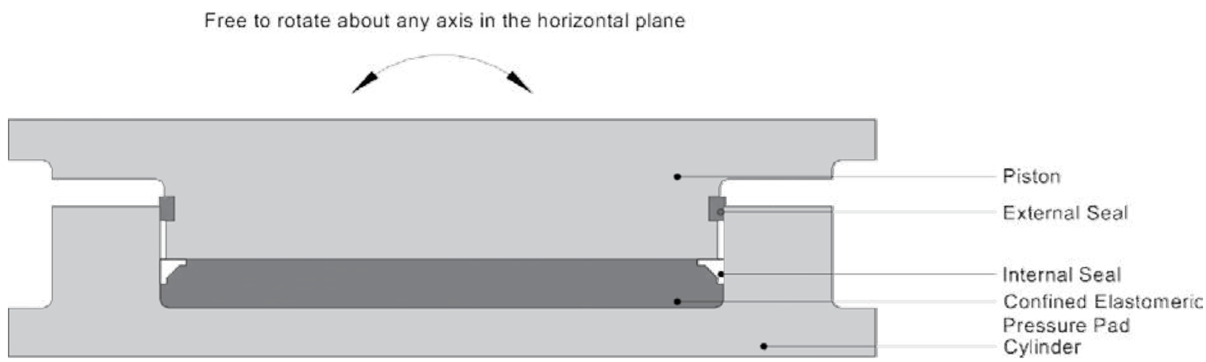


Fig. 2.1 Fixed Pot Bearing

2.1.2 *Sliding Pot Bearing*:

A type of Pot bearing which bears and transmits vertical load and allows movement in any direction in the horizontal plane and accommodates rotation about any axis in horizontal plane **(Fig. 2.2)**.

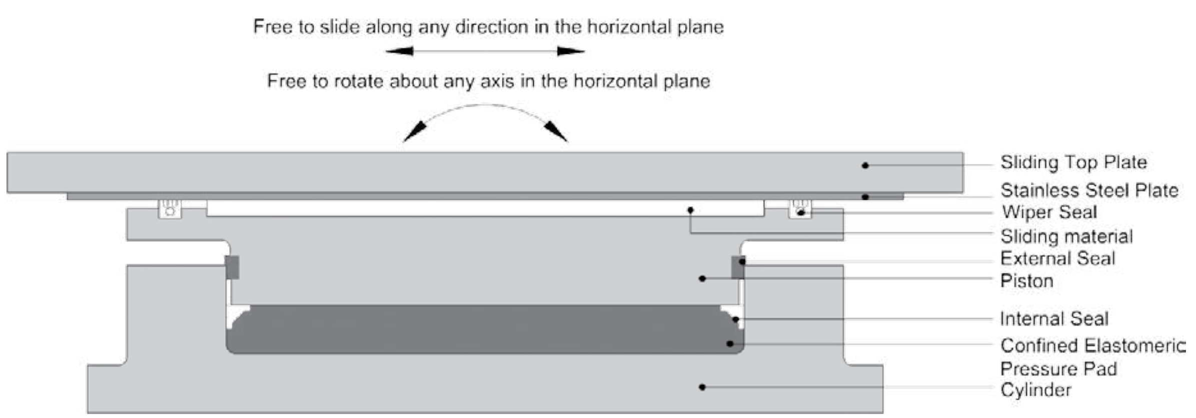
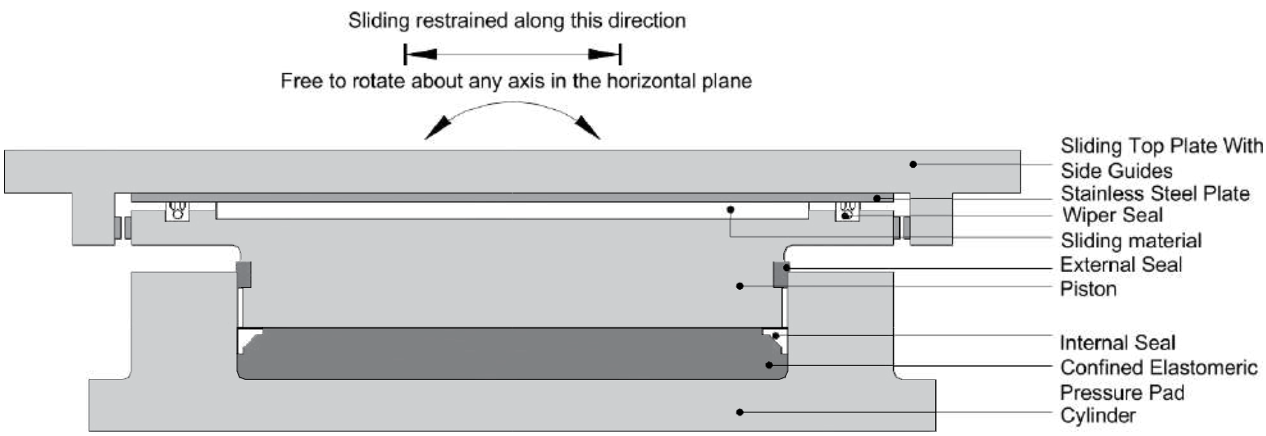


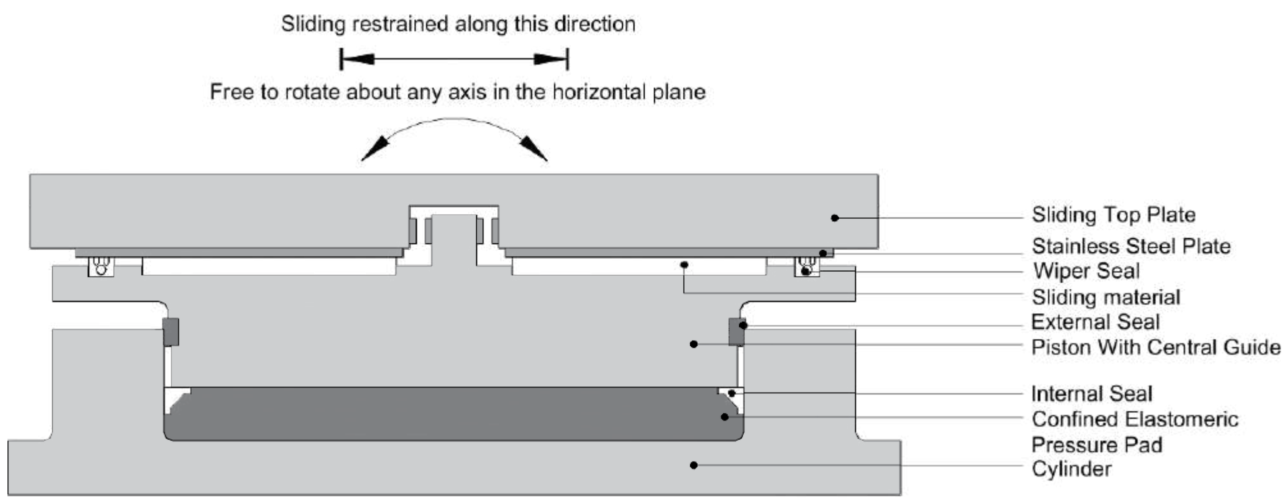
Fig. 2.2 Sliding Pot Bearing

2.1.3 *Guided Pot Bearing:*

A type of Pot bearing which along with vertical load bears and transmits horizontal force in one direction only and allows movement perpendicular to that direction and allows rotation about any axis in horizontal plane **(Fig. 2.3)**.



a) With Side Guide



b) With Central Guide

Fig. 2.3 Guided Pot Bearing

2.2 Sliding Assembly

A bearing consisting of a sliding assembly (with or without restraint in the form of guide along a desired direction to bear and transmit horizontal force) comprising of stainless steel plate attached to a metal backing plate sliding in horizontal plane over sliding material confined in recess(s) on a fixed plate. Sliding assemblies are capable to bear and transmit vertical load but are not capable to accommodate rotational movement unless provided with additional arrangement. Depending on the desired degree of freedom Sliding assemblies may be of two types as follows:

2.2.1 *Free Sliding Assembly*

A type of Sliding Assembly which bears and transmits vertical load and allows movement in any direction in the horizontal plane **(Fig. 2.4)**.

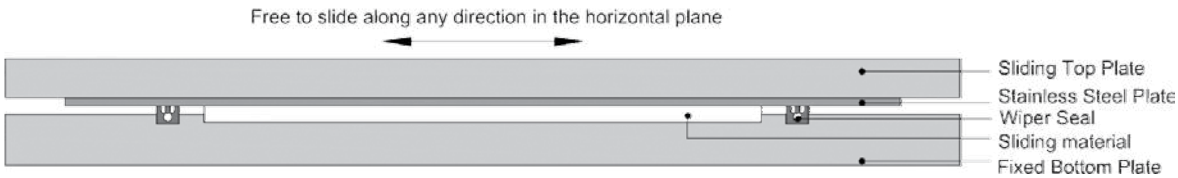
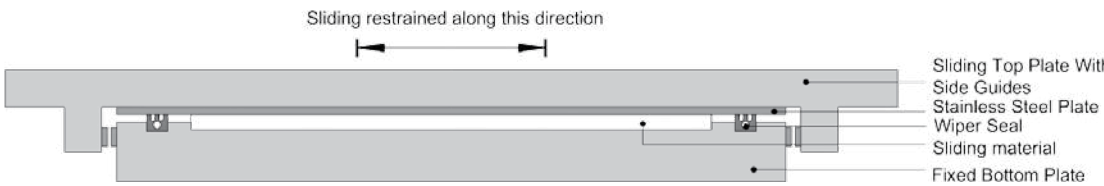


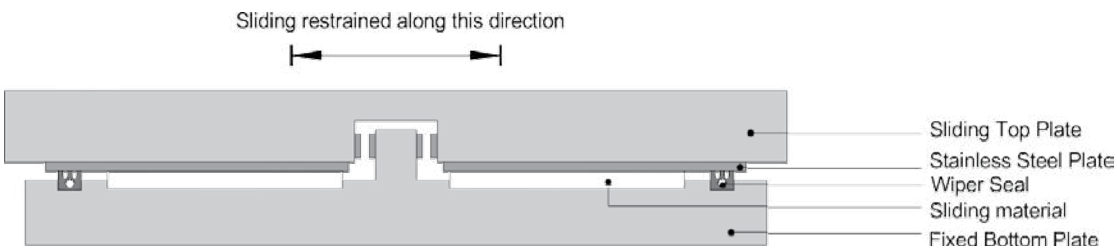
Fig. 2.4 Free PTFE Sliding Assembly

2.2.2 *Guided Sliding Assembly:*

A type of Sliding Assembly which along with vertical load bears and transmits horizontal force in one direction and allows movement perpendicular to that direction **(Fig. 2.5)**.



a) With Side Guide



b) With Central Guide

Fig. 2.5 Guided PTFE Sliding Assembly

2.3 Pin Bearing

A bearing consisting of a metal pin provided within a metal cylinder to bear and transmit horizontal force along any direction in the horizontal plane and accommodating rotational movement about any axis. Pin bearings cannot bear or transmit any vertical load **(Fig. 2.6)**.

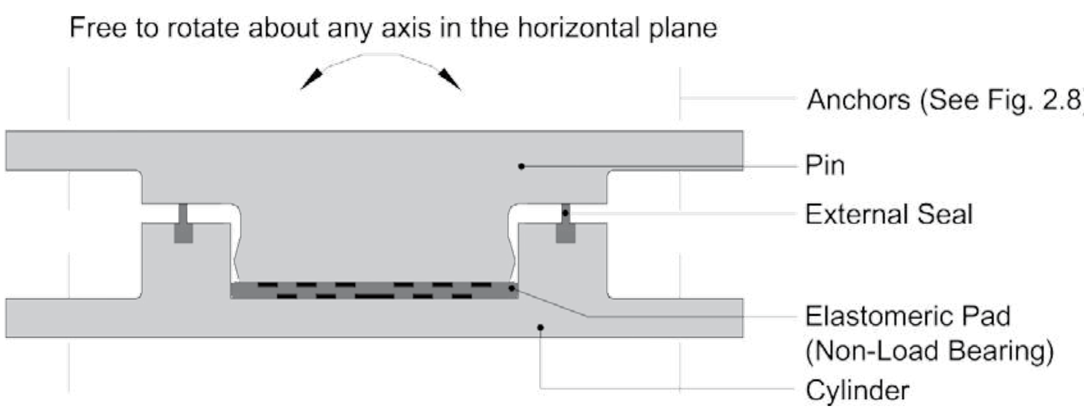


Fig. 2.6 Pin Bearing

2.4 Metallic Guide Bearing

A bearing consisting of a sliding assembly with restraint along a desired direction to bear and transmit horizontal force and capable of allowing movement in a direction perpendicular to the direction of horizontal force. Metallic Guide bearings are capable of allowing rotation only about an axis perpendicular to the plane of sliding. Metallic Guide bearing cannot bear or transmit any vertical load **(Fig. 2.7)**.

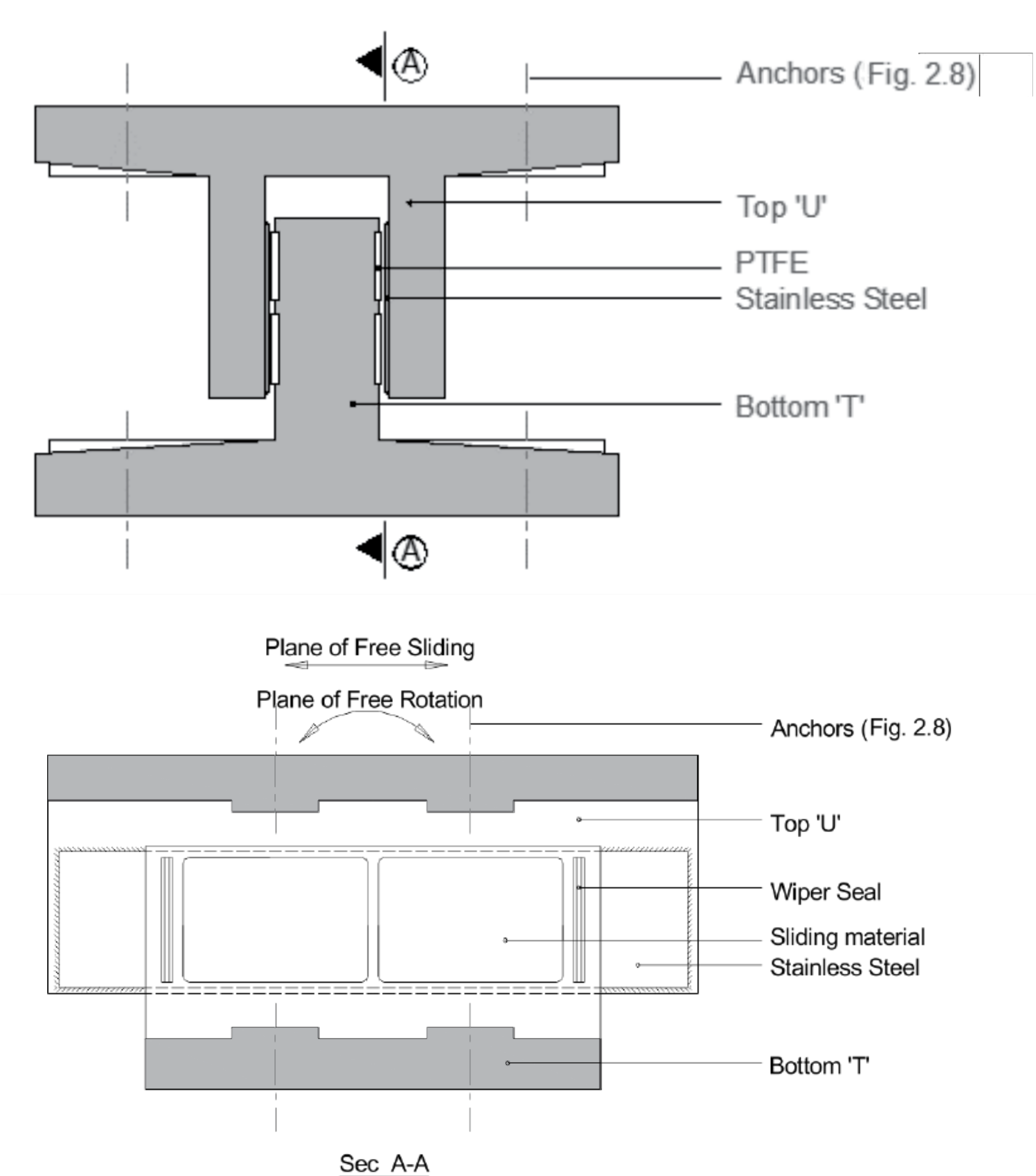


Fig. 2.7 Metallic Guide Bearing

2.5 Cylinder

A metallic cylindrical component provided with a base plate which houses the elastomeric pressure pad and piston for pot bearings and the pin for Pin bearings.

2.6 Piston

The metallic component of a Pot bearing which is housed inside the cylinder and confines the elastomeric pressure pad. For sliding or guided type Pot bearings the piston is provided with recess(s) at the top to accommodate and confine sliding material.

2.7 Confined elastomeric pressure pad

A disc of unreinforced elastomer that is confined within the cylinder by the piston of Pot bearings for accommodating rotational movement about any axis in horizontal plane and to bear and transmit vertical load.

2.8 Sliding component

A component comprising of stainless steel plate attached to a metal backing plate for sliding over sliding material.

2.9 Accumulated slide path

The sum of the relative movements between the internal seal and the pot wall resulting from variable Rotations OR the sum of relative movements at sliding interface for variable translation.

2.10 Guide

Metallic projection either from the piston which fits into a corresponding recess in the sliding component or from the sliding component parallel to two opposite edges of the piston, to bear and transmit horizontal force along a direction.

2.11 Internal seal

A sealing arrangement may be provided for preventing ingress of moisture and debris through the gap between the piston and cylinder for Pot bearings and that through the gap between the pin and cylinder for Pin bearings.

2.12 External seal

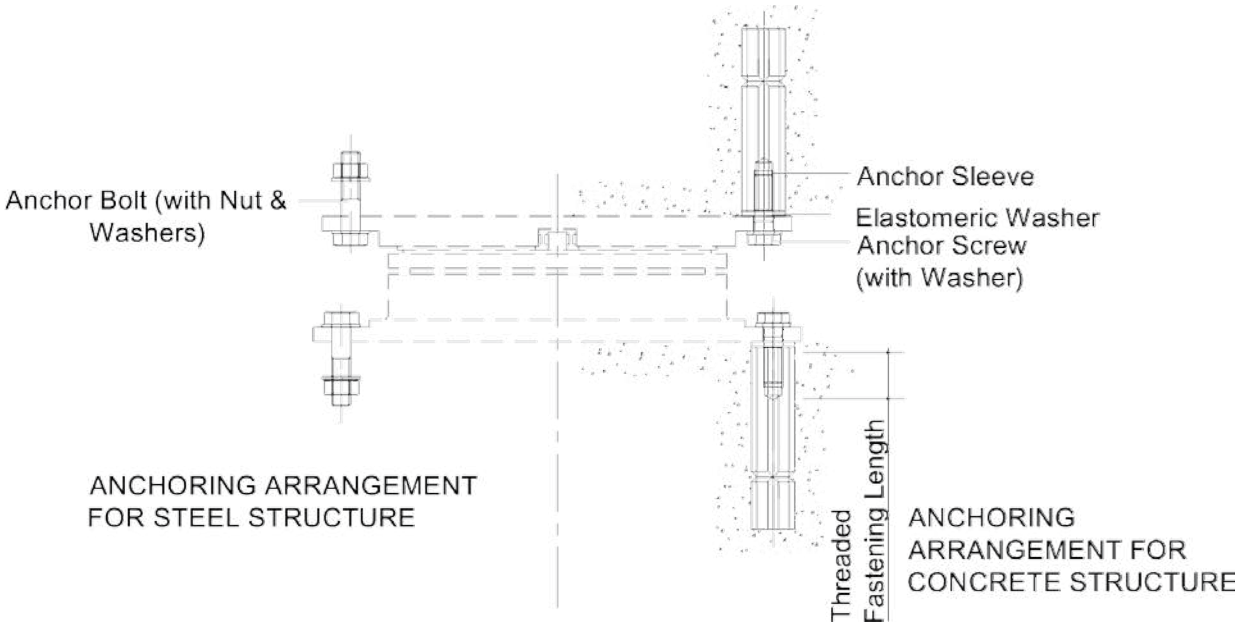
A sealing arrangement provided for preventing ingress of moisture and debris through the gap between the piston and cylinder for Pot bearings and that through the gap between the pin and cylinder for Pin bearings. The detail of external seal shown in **Figs. 2.1** to **2.3** and **2.6** are indicative and actual arrangement / detail may differ depending upon manufacturer's design.

2.13 Wiper seal

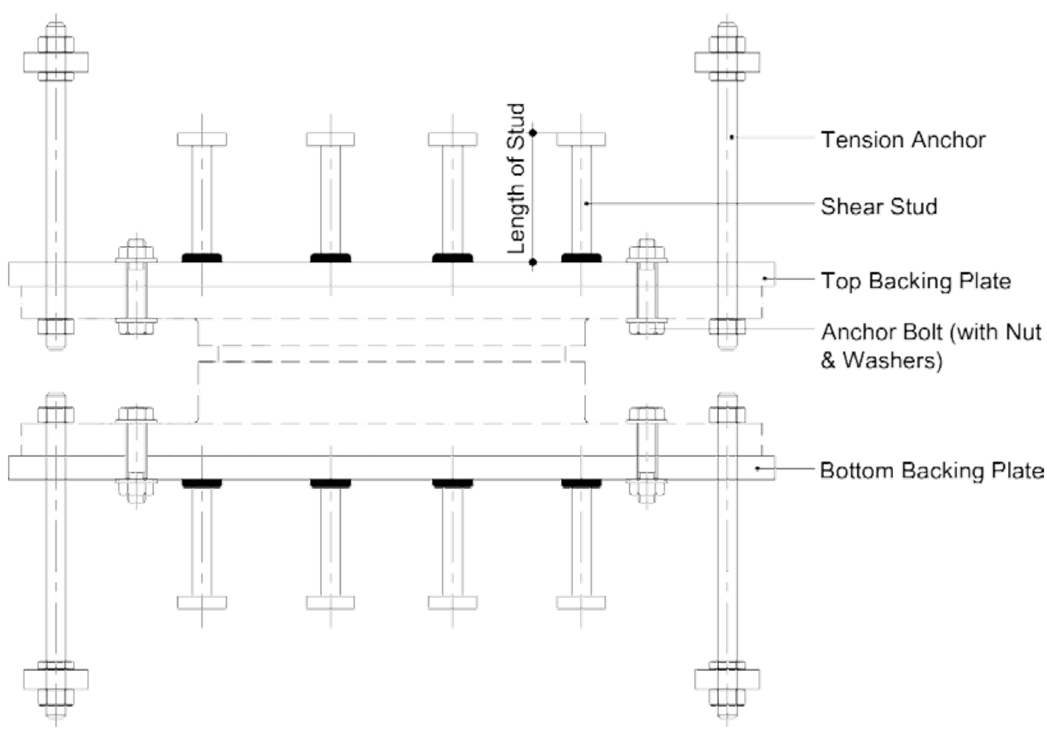
A sealing arrangement provided for retaining the lubrication and preventing contamination of the sliding surfaces. Use of wiper seal is optional.

2.14 Anchoring arrangement

An arrangement provided to fix the bearing to the structure **(Fig. 2.8)**.



a) Anchoring Arrangement with Bolt-Nut / Screw-Sleeve System



b) Anchoring Arrangement with Shear Studs And Tension Anchors

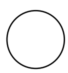
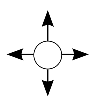
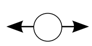
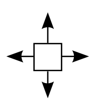
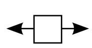
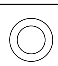
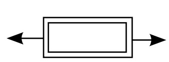
Fig. 2.8 Anchoring Arrangement

2.15 Pre-set

Setting of sliding component to a predetermined position with respect to its mean position.

3 SYMBOLS AND NOTATIONS

3.1 Symbolic Representation of Bearing Function

Symbol	Bearing Type	Resists Vertical Load	Direction of restraining horizontal force	Direction of allowing translation	Direction of allowing rotation
	Fixed Pot	Yes	Any	No	Any
	Free Sliding Pot	Yes	No	Any	Any
	Guided Sliding Pot	Yes	Unidirectional	Unidirectional	Any
	Free Sliding Assembly	Yes	No	Any	No
	Guided Sliding Assembly	Yes	Unidirectional	Unidirectional	No
	Pin	No	Any	No	Any
	Metallic Guide	No	Unidirectional	Unidirectional	Uni-directional

3.2 Notations

3.2.1 *Latin Upper Case Letters*

A = gross cross section area

A_{co} = loaded area for no eccentricity

A_{c1} = is the maximum design distribution area with a similar shape to A_{c0}

A_r = reduced area

A_s = tensile area of bolt

D = diameter of anchor sleeve, in mm

Dp = largest plan dimension of piston or outer diameter of pot cylinder, whichever is smaller, in mm

L = length of anchor sleeve, in mm

E_{cm} = short term static modulus of elasticity of concrete

E_s = static modulus of elasticity of steel, in MPa

F_{ten} = design tensile force per stud

F_{Rdu} = resistance offered by concrete in ULS

$F_{v,Rd}$ = design shear resistance of single anchor

F_w = resistance of weld, in MPa

F_{xy} = applied horizontal Force in N

K_u = thickness of guide

L_u = effective length of guide

$M_{e,d}$ = induced moment due to tilting stiffness, in N-mm

$M_{R,d}$ = induced moment due to frictional resistance, in N-mm

$M_{T,d}$ = total induced moment, in N-mm

N = axial forces, in Newton

N_{Rk} = characteristic value of resistance of the elastomeric pad

$P_{R,d}$ = design shear resistance of single shear stud

R = radius of curvature of the curved contact surface of piston and cylinder for Pot bearing, in mm

S = shape factor

S_a = accumulated slide path

S_{Ad} = actual Accumulated slide path

V = total transverse or shear force, in N

V' = total transverse or shear force per unit length, in N per millimetre

V_e = shear force due to elastomer pressure, in N

V_{Pd} = design value of anchorage resistance in Shear

3.2.2 Latin Lower Case Letters

di = diameter of confined elastomeric pressure pad, in mm

e = eccentricity

f_{cd} = permissible direct compressive strength of concrete

f_{ck} = characteristic compressive strength of the 28 day concrete cube

$f_{e,d}$ = design contact strength of elastomer, in MPa

f_k = characteristic compressive strength

f_u = ultimate strength of material, in MPa

f_{ub} = ultimate Tensile Strength of bolt

$f_{v,wd}$ = the design shear strength of the weld

fy = yield strength of material, in MPa

h = projection of PTFE/UHMWPE above the recessed portion

h_a = height of line of application of design horizontal force for guide

h_c = height of cylinder wall of Pot and Pin bearing, in mm

he = thickness of confined elastomeric pressure pad, in mm

hp = height of piston, in mm

h_{sc} = length of stud including head

kb = thickness of base of Pot and Pin bearing, in mm

k_1,k_2 = constants for determining induced moments due to tilting stiffness of confined elastomeric pressure pad

n_v = number of vehicle (Lorries)

t_p = thickness of sliding material

w = width of contact surface of the piston for Pot bearing and the pin for Pin bearing, in mm

w_e = effective width of contact surface of piston and cylinder for Pot bearing and pin and cylinder for Pin bearing, in mm

3.2.3 Greek Letters

γ_m = partial safety factor

γ_{m2} = partial safety factor for bolts, weld

γ_v = partial safety factor shear Stud

γ_μ = partial safety factor for friction

θ = design rotation angle, in radian

θ_{max} = calculated value of resultant rotation angle, in radian

θ_p = calculated value of resultant rotation angle due to permanent actions and long term effects, in radian

θ_v = calculated value of resultant positive rotation angles due to variable actions, in radian

θ'_v = calculated value of resultant negative rotation angles due to variable actions, in radian

$\theta_{v,range}$ = range of rotation angles due to extreme positions of variable actions, in radian

μ = coefficient of friction at sliding material-stainless steel sliding interface

μ_{fr} = coefficient of friction at secondary sliding interface

μ_k = characteristic value of friction coefficient between bearing and adjacent structure

v = Poisson's ratio

σ = average pressure on sliding material

3.2.4 Subscripts

d = design value

Rd = design resistance

Sd = design internal forces and moments from actions

u = ultimate limit state

3.2.5 Abbreviations

POM = polyoxymethylene (acetal)

PTFE = polytetrafluoroethylene

UHMWPE = Ultra High Molecular Weight Polyethylene

4 MATERIALS

4.1 Steel

4.1.1 Mild steel to be used for the main components of the bearings shall generally comply with grade E350BR (minimum) of IS: 2062 or equivalent. However, sub quality C of IS: 2062 or equivalent shall be used for sub-zero condition. For other components, e.g. transportation clamps etc., the grade of steel should be E250BR minimum.

4.1.2 Cast steel shall generally comply with Grade 340-570W of IS: 1030 or equivalent. Use of cast steel in sub-zero condition is allowed with Charpy Impact value similar to sub quality C of IS: 2062. Alternatively, for sub-zero condition, cast steel of suitable grade conforming to IS: 4899 may also be used.

4.1.3 The steel for forging to be used for the components of the bearings shall comply with Class 3, 3A or 4 of IS: 1875 and steel forgings shall comply with Class 3, 3A or 4 of IS: 2004 or equivalent grades of BS: 970.

4.1.4 Stainless steel shall conform to AISI 316 or AISI 316L.

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

The material shall be either polytetrafluoroethylene (PTFE) free sintered without regenerated material or Ultra High Molecular Weight Polyethylene (UHMWPE) having high material strength and low frictional properties. The pattern of dimples shall be as described in **Fig. 4.1**.

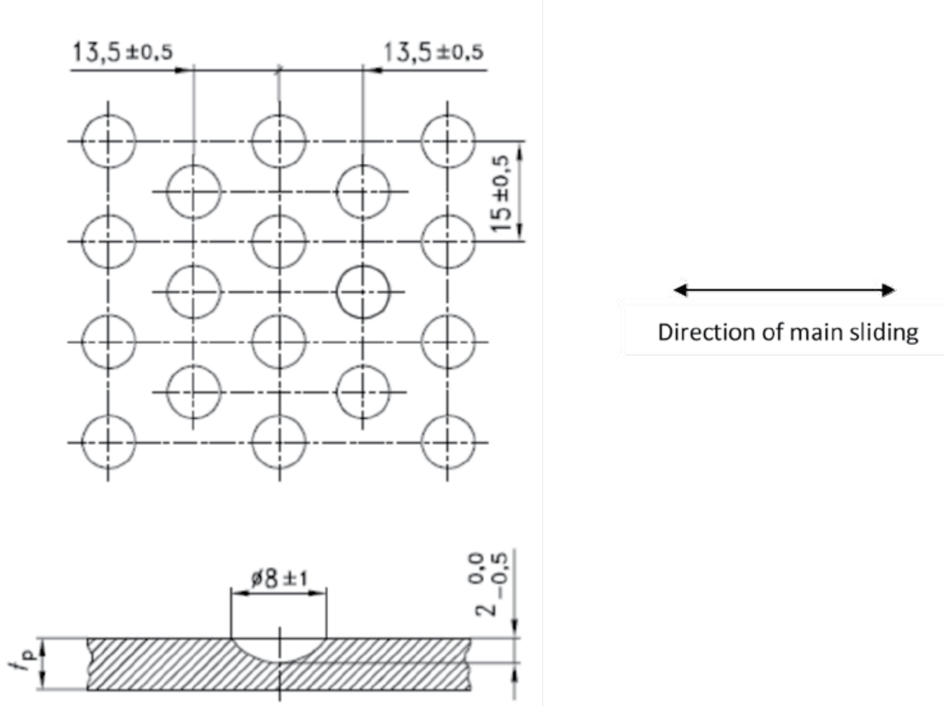


Fig. 4.1 Pattern of Dimples in Sliding Material

4.2.1 The mechanical and physical properties of PTFE shall comply with **Table 4.1**

Table 4.1 Mechanical and Physical properties of PTFE

Property	Testing standard	Requirement
Mass density	EN ISO 1183 (all parts)	p_p = 2140 to 2200 kg/m^3
Tensile strength	EN ISO 527-1 and 3	f_{ptk} = 29 to 40 MPa
Elongation at break	EN ISO 527-1 and 3	$\delta_p \geq 300$ %
Ball hardness	EN ISO 2039-1	H132/60 = 23 to 33 MPa

4.2.2 Use of modified sliding material (UHMWPE) 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 can be considered for both horizontal and vertical sliding surfaces. Use of UHMWPE shall be subjected to availability of approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading International Specifications, reference of its usage in the bearing.

4.3 Composite Material

For guides of Pot / Sliding bearings composite material (CM1) may be used. 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 4.2.** In addition, the condition of the material and its surface finish shall be checked visually.

Table 4.2 Characteristics of CM1

Bronze backing	Material: CuSn 6 Thickness: 2.1±0.15 mm Hardness HB – EN ISO 6506 (all parts): 80 to 160
Bronze interlayer	Material: CuSn 10 Saturation with PTFE-Pb: ≥ 25% Thickness: $0.25^{+0.15}_{0.0}$ mm
Composite material surface layer	Material: PTFE + Pb Composition by mass: Pb 49 to 62%, remainder PTFE Thickness: $0.01^{+0.02}_{0.0}$ mm Overlay adhesion – EN ISO 2409: minimum GT 2
Total thickness	2.48 ± 0.015 mm

4.4 Elastomer

The elastomer to be used for the components of bearings shall generally be made of Chloroprene Rubber (CR) or Natural Rubber (NR). The confined elastomer of Pot bearings shall have the properties specified in **Table 4.3**.

Table 4.3 Physical Properties of Confined Elastomer

Properties	Unit	Requirement	Test methods
Hardness	IRHD	50 ± 5	ISO 48
Minimum tensile strength - Moulded test piece	MPa	16	ISO 37 type 2
Minimum elongation at break - Moulded test piece	%	450	ISO 37 type 2

Minimum tear resistance - CR - NR	kN/m	7 5	ISO 34-1 trouser method A
Maximum compression set (%) (24 h, 70° ± 1°C) - CR - NR	% %	15 30	ISO 815 ϕ29 x 12.5mm Spacer: 9.38-25%
Accelerated Ageing (Maximum change from unaged value) Hardness - NR 7 d, 70 °C - CR 3 d, 100 °C Tensile strength - NR 7 d, 70 °C - CR 3 d, 100 °C	IRHD %	-5, +10 ±5 ±15 ±15	ISO 48 ISO 188
Elongation at break - NR 7 d, 70 °C - CR 3 d, 100 °C	%	±25 ±25	
Ozone Resistance Elongation : 30 % - 96 h, 40 °C ± 2 °C - NR 25 pphm - CR 100 pphm		No cracks	ISO 1431-1

4.5 Internal seal

To prevent the extrusion of confined elastomer, under load, between piston and cylinder of Pot bearing, internal seal shall be provided. The following seals can be considered as suitable, according to the state of the art.

4.5.1 *Brass seal*

The internal brass seal shall be fitted into a formed recess in the upper edge of the elastomeric pad and shall consist of a number of split rings formed to the internal diameter of the pot. When fitted, the gap between the ends of the ring shall not exceed 0.5 mm and the gaps in adjacent rings shall be equally disposed around the perimeter of the pot. Where possible no gap should coincide with the point of maximum rotation movement on the pot wall.

The material used for the brass seal shall be grade CuZn37 or CuZn39Pb3, as specified in EN 12163 and EN 12164 respectively or CuZn37 / CuZn40 as per IS: 410 and in accordance with Clause 6.2.4.

4.5.2 *POM seal*

POM (Poly Oxy Methylene) sealing chain shall consist of individual interlocking elements made of moulded polyoxymethylene, which can adapt easily to deformation. Material properties of POM sealing chain shall be as specified in **Table 4.4.**

Table 4.4 Physical and Mechanical Properties of POM

Property	In accordance with	Requirements
Density	ISO 1183	1410 kg/m^3 ± 20.0 kg/m^3
Melt flow index MFI 190/2, 16	ISO 1133	10 g/min ± 2.0 g/min
Ultimate tensile strength	ISO 572-2	≥ 62 MPa
Ultimate strain	ISO 572-2	≥ 30%

4.5.3 Carbon filled PTFE seal

The material composition of carbon filled PTFE seal shall consist of PTFE + 25 % carbon. The material properties shall be in accordance with the requirements of **Table 4.5** below.

Table 4.5 Physical and Mechanical Properties of carbon filled PTFE seal

Properties	In accordance with	Requirements
Density	ISO 1183	2100 kg/m^3 to 2150 kg/m^3
Ultimate tensile strength	EN ISO 527-2	≥ 17 MPa
Ultimate strain	EN ISO 527-1	≥ 80%
Ball hardness	EN ISO 2029-1	≥ 40 N/mm

The material properties shall be verified on samples taken from finished tubes at 23 °C and 50% humidity. The ultimate tensile strength and the ultimate strain shall be determined with a speed C = 50 mm/min on test samples with a PTFE thickness of 2 mm ± 0.2 mm in accordance with EN ISO 527-2. The ball hardness shall be determined on samples with a minimum thickness of 4.5 mm.

4.5.4 *Stainless steel seal*

The sealing ring shall be made from stainless steel strip formed into an equal or unequal angle section inserted between the elastomeric pad and the pot wall.

The material used for the stainless steel seal shall be as per AISI 316 or AISI 304LN.

4.6 External seal

External seal of suitable profile made of silicone rubber or chloroprene rubber shall be provided for preventing ingress of moisture and debris through the gap between the piston and cylinder for Pot bearings and that of the pin and cylinder for Pin bearings.

4.7 Wiper seal

Wiper seal of suitable profile made of Chloroprene Rubber (CR) or Nitrile Butadiene Rubber (NBR) may optionally be provided for retaining the lubrication and preventing contamination of the sliding surfaces.

4.8 Fasteners

Bolts, screws, nuts and lock nuts shall generally conform to IS:1363, IS:1364, IS:1365, IS:2269, IS:3138, IS:6761, IS:6639 or equivalent as appropriate with mechanical properties conforming to IS:1367 or equivalent. Threads shall generally conform to IS: 4218 or equivalent. Washers shall conform to IS: 2016, IS: 6610 or equivalent as appropriate.

4.9 Shear Stud

Shear studs shall conform to SD1 / SD2 of ISO 13918.

5 DESIGN

5.1 General

5.1.1 Local effects of load / force and movements to be considered in designing the bearings shall be determined by suitable global analysis of the structure with idealised boundary condition under any critical combination of loads and forces that can coexist in accordance with the requirements of IRC:6.

5.1.2 Resistance due to friction at the sliding interface of the bearing, if any, shall be ignored for idealising the boundary conditions in global analysis of the structure. However, induced force generated due to friction at sliding interface shall be considered in the design of bearings and adjacent (supported/supporting) structures.

5.1.3 Load / movement data for design of bearings shall be furnished in SLS-ULS format as per **Annexure A,** ‘Typical Format of Furnishing Data for Design of Bearings’.

5.1.4 For design of Pot bearings or part thereof the design horizontal force to be considered shall be the resultant of the coexisting active horizontal forces, determined from global analysis, and induced horizontal forces, generated due to friction at sliding interface (if any).

5.1.5 For design of bearings or part thereof and the adjacent structures the resultant of the coexisting moments ($M_{T,d}$) produced due to design horizontal force and that induced due to resistance to rotation shall be considered.

5.1.5.1 For the verification of the adjacent structural parts, the maximum value of the restraint moment, i.e. the induced moment resulting from resistance to rotation due to the effect of tilting stiffness of elastomeric pressure pad ($M_{e,d}$) shall be determined as per either of the following methods:

Method 1 (Applicable when Type test data are available):

$M_{e,d} = 32 \times di^3 \times (F_0 + (F_1 \times \theta_p) + (F_2 \text{ x } \theta_v))$

F_0, F_1 & F_2 shall be taken from certified Type test data. Type test shall conducted in laboratory of international repute eligible to test in accordance with annex D of EN1337-5.

di = diameter of elastomeric pressure pad in mm

θ_p = Resultant rotation angle due to permanent actions and long term effects, in radian **(Fig. 5.2).**

θ_v = Resultant positive rotation angles due to variable actions, in radian **(Fig. 5.2)**.

Method 2 (Applicable when Type test data are not available):

$M_{e,d} = di^3 \text{ x } (k_1.\theta_p + k_2.\theta_v)$, where,

k_1 and k_2 shall be as per **Table 5.1**. Intermediate values may be obtained by linear interpolation.

Table 5.1 Values of Constants k_1 and k_2

di / he	k_1	k_2
15	2.2	101
12.5	1.8	58.8
10	1.5	30.5
7.5	1.1	13.2

di = diameter of elastomeric pressure pad in mm

θ_p = Resultant rotation angle due to permanent actions and long term effects, in radian **(Fig. 5.2)**

θ_v = Resultant positive rotation angles due to variable actions, in radian **(Fig. 5.2)**.

5.1.5.2 Induced moment resulting from resistance to rotation caused by the friction at the piston-cylinder contact surface due to coexisting horizontal force from permanent action shall be determined as follows:.

$M_{R,d} = 0.2 \times C \times V_d$ where,

C = the perpendicular distance from the point of action of horizontal force on cylinder wall to the axis of rotation in mm. **(Fig. 5.1)**.

V_d = Coexisting horizontal force in N

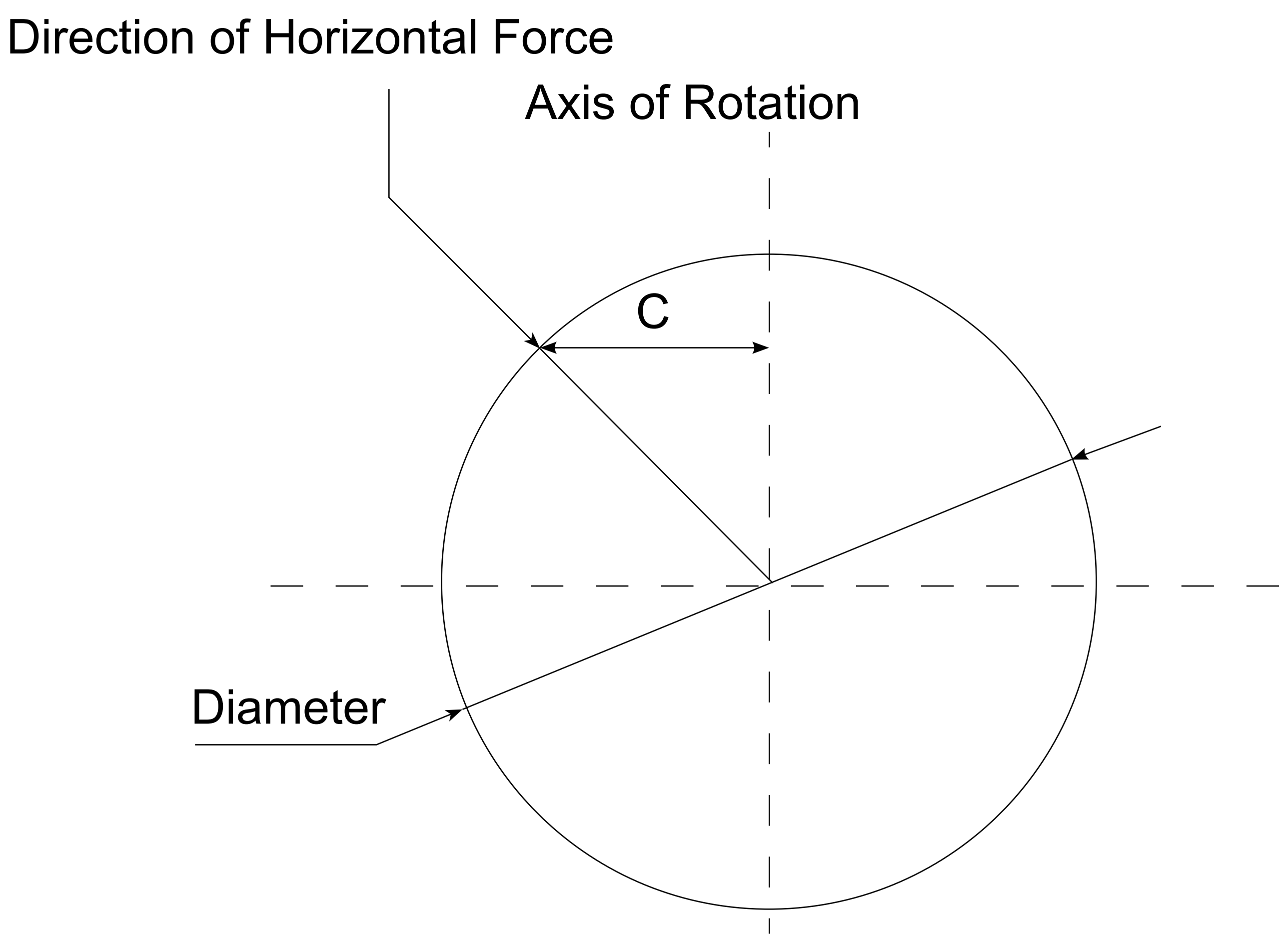


Fig. 5.1 Moment Arm for Rotation Resistance due to Friction

Note: This moment however may be ignored for transient horizontal forces, as change in rotation is not likely to occur instantaneously during application of transient horizontal force.

5.1.6 For Pot bearings total induced moment will be $M_{T,d} = M_{E,d} + M_{R,d}$ and for Pin bearings total induced moment will be $M_{T,d} = M_{R,d}$

5.1.7 The relationship between the permanent and variable rotation angles is shown in **Fig. 5.2**.

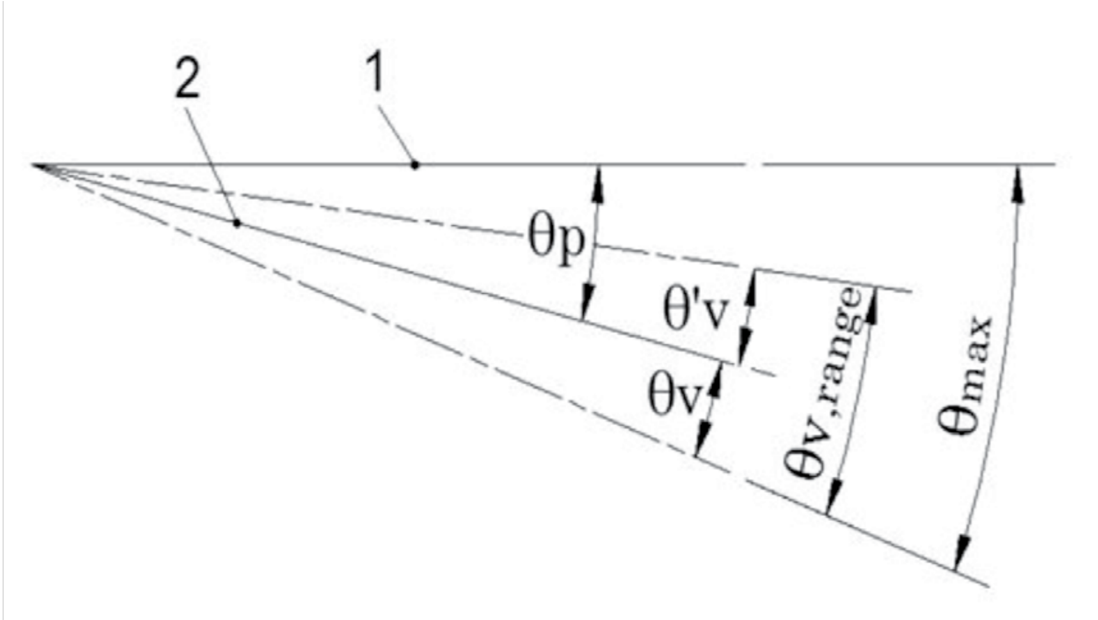


Fig. 5.2 Diagramatic Representation of Rotation Angles

1 Starting position (after installation),

2 Position due to rotation θ_p caused by permanent actions

θ_v = positive rotation angles due to variable actions.

θ'_v = negative rotation angles due to variable actions.

$\theta_{v,range} = \theta_v + \theta'_v$ = range of rotation angles due to extreme positions of variable actions.

$\theta_{max} = \theta_p + \theta_v$

Under the frequent combination of actions the difference in rotation $\theta_{v,range}$ shall not exceed 0.005 rad.

The design rotation (θ) shall be determined by as follows $\theta = \theta_{mas}$ + 0.005 radians. Maximum value of design rotation shall not exceed 0.03.

5.1.8 Variable rotations result in an accumulated slide path, which affects the durability of the internal seal.

When required the actual accumulated slide path $S_{A,d}$ shall be calculated with data provided by the bridge designer using the following formula:

$S_{A,d} = n_v \; x \; \theta_{v,range} \times \frac{di}{2}$

$S_{A,d} \leq 5 \times S_T$, where

$S_{A,d}$ = actual accumulated slide path due to characteristic traffic loads

n_v = number of vehicles for the intended life of bearing

S_T = accumulated slide path

= 500 *m* for Stainless Steel seal

= 1000 *m* for Brass seal

= 2000 *m* for POM seal and Carbon filled PTFE seal

It is advised that $\theta_{v,range}$ is determined using an appropriate single vehicle model (Lorries / trucks).

5.1.9 Design horizontal displacement for both Pot and Metallic Guide Bearings shall be increased by ± 20 mm in both the directions of movement. However, a minimum total displacement of ± 50 mm in the longitudinal direction and ± 20 mm in the transverse direction shall be considered. The values are not applicable if the bearings are mechanically restrained. They shall not be used where stresses are being calculated.

In addition, for Metallic Guide Bearings, the vertical design movement capacity shall be at least the following:

- 15 mm upwards
- 10 mm downwards

5.1.10 The line of action of resultant horizontal force shall be considered at the middle of the contact width (Clauses 5.3.1.4.1 and 5.3.1.4.2) of the piston and cylinder for Pot bearings and that of the pin and cylinder for Pin bearings.

5.2 Design Parameter

5.2.1 *Design resistance of the adjacent concrete structure*

5.2.1.1 The load transfer from the Bearing to the adjacent structure shall be concentrated but uniformly distributed load for which the resistance of the adjoining concrete structure in ultimate load condition is to be determined which shall meet or exceed the acting load values. The resistance of the concrete structure shall be calculated from the expression below. Design resistance may further be enhanced taking into account the effect of reinforcement as per discretion of structural engineer. Concrete zones below and adjacent to the bearing shall be designed as per Clause 16.11.2 of IRC: 112.

For a uniform distribution of load on an area A_{c0} **(Fig. 5.3)** the concentrated resistance force may be determined as follows:

$$F_{Rdu} = A_{co} \times f_{cd} \times \sqrt{\frac{A_{c1}}{A_{c0}}} \leq 3 \times f_{cd} \times A_{c0}$$

where:

F_{Rdu} = resistance offered by concrete in ULS condition loading

f_{cd} = permissible direct compressive strength of concrete, calculated as:

f_{cd} = $\frac{0.67 \times f_{ck}}{\gamma_c}$

f_{ck} = characteristic compressive strength of the 28 day concrete cube

γ_c = 1.5 for concrete

A_{c0} = loaded area

A_{c1} = the maximum design distribution area with a similar shape to A_{c0}

The design distribution area A_{c1} required for the resistance force F_{Rdu} should correspond to the following conditions:

- the height for the load distribution in the load direction should correspond to the conditions given in **Fig. 5.2**
- the centre of the design distribution area A_{c1} should be on the line of action passing through the centre of the loaded area A_{c0}

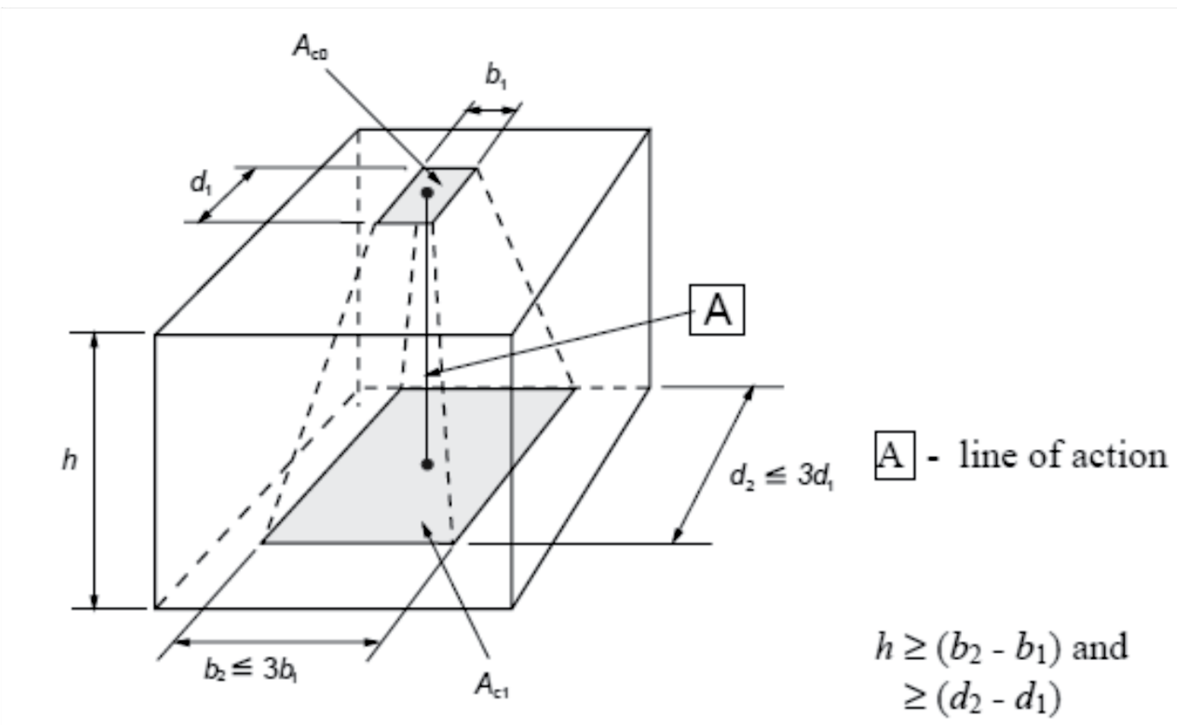


Fig. 5.3 Pattern of Load Dispersion and Distribution Area

5.2.1.2 Effect of eccentricity (e) due to induced moment and horizontal force in critical combination of load shall be taken into account considering reduced contact loaded area (Ar), determined from **Annexure B**. In case of separation of parts due to eccentricity, special measures shall be taken. e.g., specially designed tension anchors as per ACI 318M or CEN/TS 1992-4-1 may be provided.

5.2.1.3 Limiting strain for concrete in ULS condition shall be considered as 0.0035.

5.2.2 Yield strength and UTS values of different grade steel as per their thicknesses shall be considered as per IS: 2062 or equivalent International standard for rolled steel and IS: 1030 or equivalent International standard for cast steel.

Limiting strain for steel in ULS condition shall be considered as 0.002 + $\frac{f_y}{1.15\,E_s}$

5.2.3 *Particular recommendations for confined elastomeric pressure pad*

5.2.3.1 Design resistance of confined elastomeric pressure pad depends on the effectiveness of the internal seal preventing it from extruding between the piston and the cylinder wall and as such shall be verified by load testing of assembled bearing.

5.2.3.2 The design maximum axial force N_{sd} in ULS condition shall meet the following condition under the critical combination of actions:

$N_{sd} \leq N_{Rd}$

Where:

$N_{Rd} = \frac{N_{Rk}}{\gamma_m}$ is the design value of resistance of the elastomeric pad

N_{Rk} is the characteristic value of resistance of the elastomeric pad

The characteristic value of the resistance shall be determined from:

$N_{Rk} = \frac{\pi}{4} \times di^2 \times f_{e,k}$, where:

di is the diameter of elastomeric pad (mm)

$f_{e,k}$ is the characteristic contact strength of the elastomer given by $f_{e,k}$ = 60 N/mm²

The partial factor $\gamma_m = 1.3$

NOTE 1: The compressive resistance $f_{e,k}$ of the elastomer in pot bearings, that leads to N_{Rk} is limited by the effectiveness of the seal preventing the elastomer from extruding between the piston and the pot wall.

NOTE 2: Elastomeric pad including internal seal having higher characteristic contact strength ($f_{e,k}$) may be used subjected to the availability of approved documents from International Approval bodies like ETA, FHWA or similar acceptance by other leading International Specifications, reference of its usage in the bearing application, satisfactory and proven test and performance records etc.

5.2.3.3 Minimum average stress in confined elastomeric pressure pad of Pot bearing, under any critical combination of loads and forces that can coexist in SLS condition, shall in no case be less than 2 *MPa*.

5.2.3.4 The dimension of the confined elastomeric pressure pad shall be such that at design rotation the deflection at the perimeter shall not exceed 15% of the pad thickness. (**Fig. 5.4**).

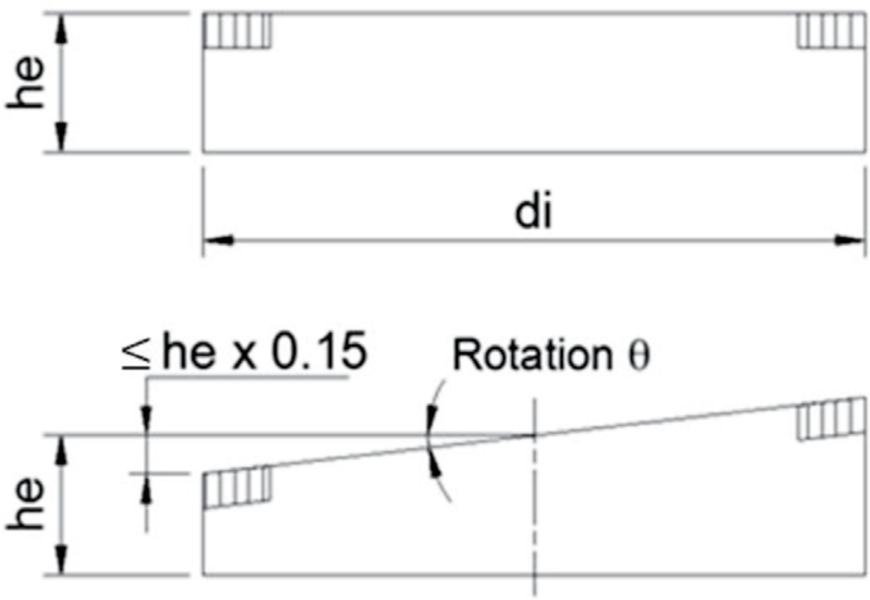


Fig. 5.4 Pattern of load dispersion and distribution area

5.2.3.5 The minimum thickness of the confined elastomeric pressure pad shall not be less than 1/15th of its diameter or 16 mm, whichever is higher and the diameter shall not be less than 150 mm.

5.2.4 Particular recommendations for confined Sliding Material

5.2.4.1 The permissible combination of the materials (sliding material and mating surfaces) to be used for sliding interfaces shall be as given in **Table 5.2**. The Sliding material surface shall be lubricated in accordance with clause 6.3.2.

Table 5.2 Sliding Surfaces

Flat Sliding Surface		**Guides**	
PTFE (Unfilled and dimpled) / UHMWPE (Dimpled)	Stainless Steel (SS)	PTFE (Unfilled) / UHMWPE Composite Material (CM1)	Stainless Steel (SS)

5.2.4.2 Sliding material shall be located into recess of a sufficiently rigid metal backing plate by confinement and shall be in form of dimpled large sheets. The thickness of the Sliding material and its protrusion from the recess should be related to its maximum plan dimension in accordance with **Table 5.3**.

Table 5.3 Thickness 't_p' and protrusion '*h*' of Sliding Surfaces

Design values	Flat sliding surfaces	Guides	
	PTFE	PTFE	CM1
Thickness 't_p' in mm	$2.2h \leq t_p \pm 8.0$	5.5	2.5
Protrusion '*h*' in mm	$h = 1.75 + \frac{L}{1200} \geq 2.2$ '*L*' diameter or diagonal distance of sliding material in mm	2.3 ± 0.2	1 ± 0.1

The tolerance on the protrusion '*h*' is ±0.2 mm for '*L*' less than or equal to 1200 mm and ±0.3 mm for '*L*' greater than 1200 mm. The protrusion "*h*" shall be verified at marked measuring points, where the corrosion protection coating shall not exceed 300 μm. There shall be at least two measuring points, suitably located.

5.2.4.3 *Sliding Surface for Guides (PTFE)*

Dimensions 'a' shall not be less than 15 mm and the modified shape factor shall be greater than 4 **(Fig. 5.5)**.

$S = \frac{A_p}{u \times h} \times \frac{t_p - h}{h}$ where,

h = Projection of PTFE above the recessed portion

u = Perimeter of PTFE free to bulge.

A_p = Area of sliding surface (PTFE) in contact i.e. under load.

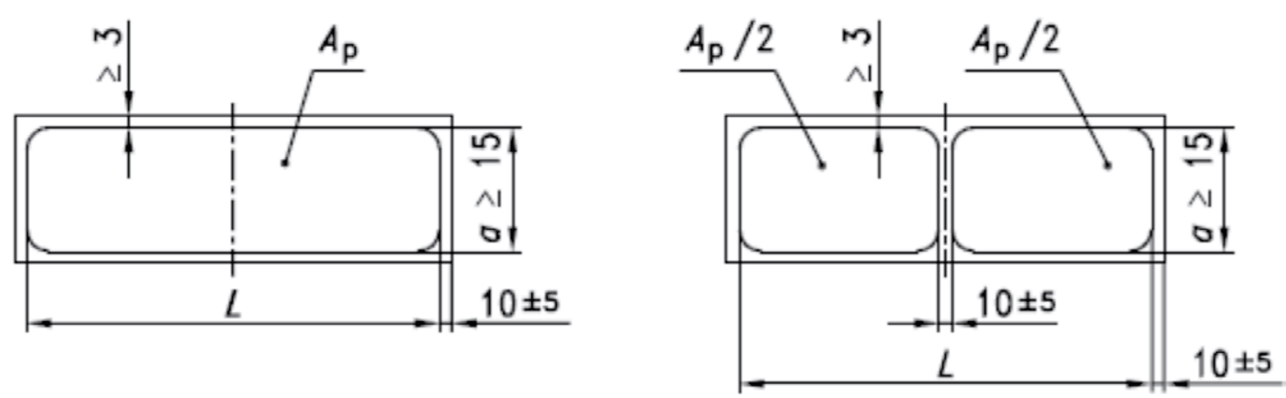


Fig. 5.5 Examples of Recessed Sliding Surface for Guides

5.2.4.4 Composite materials shall only be used where self-alignment between the mating parts of the bearing is possible. Width "a" shall be equal to or greater than 10 mm.

5.2.4.5 The characteristic compressive strengths of Sliding materials are given in **Table 5.4**

Table 5.4 Characteristic Compressive Strength (f_k) of Sliding Material

Material	Application Condition	f_k (MPa)
PTFE (Unfilled)	Main bearing Surface and guides	90
CM1	Guides	200

These values are valid for temperatures up to 30° C for PTFE. For bearing exposed to a maximum temperature in excess of mentioned respective values, the values shall be reduced by 2 percent per degree in order to reduce creep effects of the PTFE respectively. No such correction is required for composite material CM1.

5.2.4.6 The design maximum axial force N_{sd} in ULS condition shall meet the following condition under the critical combination of actions:

$$N_{Sd} \leq \frac{f_k}{\gamma_m} \times A_r$$

Where:

N_{sd} is the design value of the axial force due to the design values of action

f_k is the characteristic compressive strength given in **Table 5.4**.

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, which is caused by both mechanical and geometrical effects. A_r shall be calculated on the basis of **Annexure B**. Separation of part is not allowed for sliding material.

For guides eccentricity can be neglected.

NOTE: The recommended value is γ_m= 1.4

5.2.4.7 For bearing with sliding surface as given in **Table 5.5**, the co-efficient of friction μ_{max}, for verification of the bearing and the structure in which it is incorporated shall be calculated as per expression below. The effect of friction at the sliding interface shall not be used to relieve the effects of externally applied horizontal forces.

Coefficient of friction for PTFE.

For flat sliding interfaces combined with dimpled and lubricated PTFE sheets and stainless steel, the co-efficient of friction μ_{max} is determined as a function of the average pressure σ_p (MPa) under maximum vertical load in ULS condition, as follows

$$0.03 \leq \mu_{max} = \frac{1.2}{10+\sigma_p} \leq 0.08$$

NOTE 1: For zones where the minimum effective bearing temperature doesn't fall below -5° C the coefficient of friction values for PTFE sliding surfaces as worked out from the above expressions may be multiplied by a factor of 2/3.

For guides with a combination of sliding materials given in **Table 5.5**, the coefficient of friction shall be considered to be independent of contact pressure and the following values shall be used.

Table 5.5 Co – efficient of Friction (μ_{fr}) for Secondary Sliding Surfaces

Application	Sliding Interface	μ_{fr}
Guides	SS – PTFE	0.08
	SS – Composite Material (CM1)	0.20

NOTE: For guides, effect of induced frictional force due to resistance to translation shall not be applicable for transient force.

5.2.4.8 When UHMWPE is used as sliding material, relevant ETA / FHWA documents shall be referred to determine the parameters described in Clause 5.2.4.1 to 5.2.4.7.

5.3 Design Philosophy

5.3.1 Particular recommendations for design of Pot bearings

Stress distribution through the bearing component adjacent to the (supported/supporting) structure as well as on the structure itself due to active load, force and induced force and moment produced due to resistance to movement and rotation in ULS condition shall be determined with due considerations to the relative stiffness and interaction of the bearing component and the adjacent structure by a suitable method e.g. three dimensional finite element (3D-FEM) method of analysis. In absence of elaborate 3D-FEM analysis, design procedure specified in Clause 5.3.1.2 may be adopted to determine the dimensions of bearing components. However for Pot bearings of vertical load capacity 10,000 kN or higher in SLS condition or if horizontal load is more than 25% of vertical load in SLS condition, the pot cylinder shall always be analysed by three-dimensional finite element method of analysis. Only internationally accepted, authentic software shall be used for carrying out 3D-FEM analysis.

5.3.1.1 To carry out 3D-FEM analysis, bearing component and the adjacent structure shall be modelled together. For concrete structure, a block of concrete shall be considered for modelling together with the adjacent bearing component. The area of the block shall be geometrically similar to the contact area and also the largest area that can be contained in the plane of contact of bearing and structure. The depth of the concrete block shall be equal to the minimum available depth of the adjacent component of the concrete structure over the area of the block. The depth of concrete block need not exceed the largest dimension (diameter or diagonal) of the bearing component along the contact plane.

5.3.1.1.1 For concrete elements, Poisson's ratio (v) may be assumed as 0.2, and modulus of elasticity (E_{cm}) may be considered as per IRC: 112 depending upon the concrete strength class.

For steel elements, static modulus of elasticity, E_s, may be considered as 2×10^5 Mpa and the Poisson's ratio (v) may be considered as 0.3.

Non-linear analysis is preferred while carrying out FEM.

5.3.1.1.2 The confined elastomeric pressure pad to be considered to act as fluid exerting fluid pressure under vertical load. In addition, design horizontal force that may coexist shall be taken into account for carrying out 3D-FEM analysis.

5.3.1.1.3 Maximum strain in bedding grout / concrete shall not exceed the limiting strain of concrete (refer Cl. 5.2.1.3) under any critical load combination in ULS condition.

5.3.1.1.4 For steel bearing components of Pot, maximum strain under any critical load combination shall not exceed limiting strain (refer Cl. 5.2.2) in ULS condition.

5.3.1.2 *Simplified Design Rule*

5.3.1.2.1 In absence of 3D-FEM analysis, load dispersion angle through bearing component(s) and to the adjacent structure shall be taken as 45°.

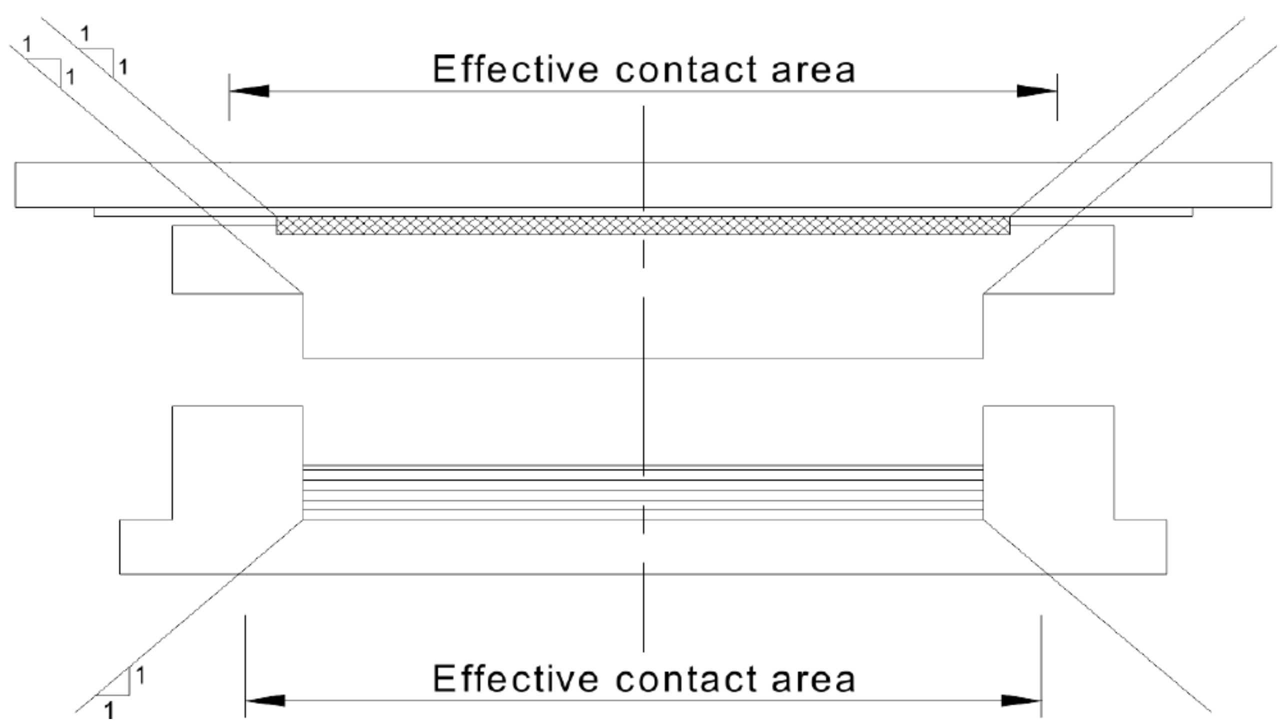


Fig. 5.6 Load Dispersion through Bearing Components

5.3.1.2.2 In absence of 3D-FEM analysis, the dimensions of the cylinder shall be determined using expressions given in the following.

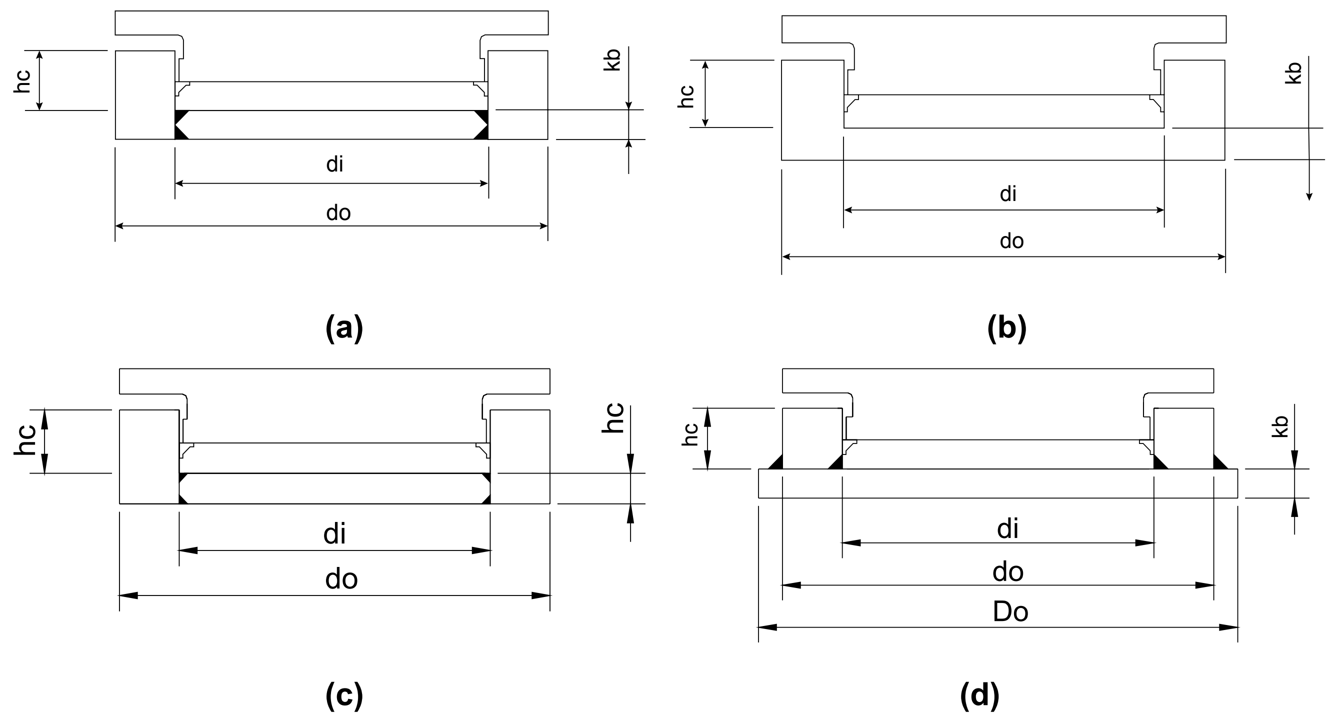


Fig. 5.7 Types of Pot Construction

5.3.1.2.3 *Pot walls subjected to tensile force*

$V_{sd} \leq V_{Rd}$ Where:

$V_{sd} = V_{e,sd} + V_{Fxy,sd}$

$$V_{e,Sd} = \frac{4 \times N_{Sd} \times he}{\pi \times di}$$

$$V_{Fxy,Sd} = \sqrt{V_{Fx,Sd}^2 + V_{Fy,Sd}^2}$$

$$V_{Rd} = \frac{f_y \times A_R}{\gamma_m}$$

Where = $A_R = (do - di) \times hc$

5.3.1.2.4 *Pot walls subjected to shear force:*

$V'_{sd} \leq V'_{Rd'}$ Where:

$$V'_{Sd} = \frac{V_{e,Sd} + 1.5 \times V_{Fxy,Sd}}{di}$$

$$V'_{Rd} = \frac{f_y \times (do - di)}{2 \times \gamma_m \times \sqrt{3}}$$

5.3.1.2.5 *Pot base subjected to tensile force:*

$V_{sd} \leq V_{Rd}$ Where:

$V_{sd} = V_{e,sd} + V_{Fxy,sd}$

$$V_{Rd} = \frac{f_y \times A_P}{\gamma_m}$$

Where $A_p = do \times kb$

5.3.1.2.6 Full Penetration butt weld connecting the pot base to the pot wall within the pot wall **(Fig. 5.7 (b)** and Clause 6.2.1)

$V_{sd} \leq V_{Rd}$ Where:

$V_{sd} = V_{e,sd} + V_{Fxy,sd}$

$$V_{Rd} = \frac{f_y \times A_P}{\gamma_m}$$

Where $A_p = do \times kb$

Also refer **Annexure E.**

5.3.1.2.7 Partial penetration butt welds connecting the pot base to the pot wall within the pot wall **(Fig. 5.7 (c)** and Clause 6.2.1)

$V_{sd} \leq V_{Rd}$ Where:

$V_{sd} = V_{e,sd} + V_{Fxy,sd}$

$V_{Rd} = 2 \times F_{w,Rd}.\ di$

Where $F_{w,Rd}$ is Design Resistance of Partial penetration butt Weld calculated as per **Annexure E**

5.3.1.2.8 Fillet welds connecting the pot wall to the top of the pot base **(Fig. 5.7 (d)** and Clause 6.2.1)

$V'_{sd} \leq V'_{Rd'}$ Where:

$V'_{Rd} = \pi \times F_{w,Rd} (di + do)$

Where $F_{w,Rd}$ is Design Resistance of Fillet Weld calculated as per **Annexure E**

NOTE: The recommended values of partial factor γ_m in 5.3.1.2.3 to 5.3.1.2.6 may be considered as follows:

γ_m = 1.1 for cast steel

= 1.0 for rolled steel

5.3.1.3 Thickness of pot base shall not be less than 2.5% of the inner diameter of the pot cylinder. Thickness of the steel backing plate of stainless steel for sliding component shall not be less than 4% of the maximum dimension (diameter or diagonal) in plan. However, minimum thickness of any steel component or part thereof shall in no case be less than 12 mm.

5.3.1.4 The contact face of the piston may be designed as flat in accordance with Clause 5.3.1.4.1 provided that the width of the piston contact face, w, is less than 15 mm **(Fig. 5.8**).

Fig. 5.8 Details of Flat Piston Contact Face

The mechanical resistance of contact faces shall be verified for the fundamental combination of actions in accordance with Clause 5.3.1.4.1 or 5.3.1.4.2.

5.3.1.4.1 Flat contact surface

Flat contact faces shall be verified, so that:

$V_{sd} \leq V_{Rd}$ Where:

V_{sd} is the design value of the horizontal force (N)

$$V_{Rd} = \frac{f_y \times di \times w}{1.5 \times \gamma_m}$$

w = width of piston face in mm,

fy = yield strength of material, in MPa

di = inner diameter of pot in mm

γ_m = 1.1 for cast steel

= 1.0 for rolled steel

5.3.1.4.2 Curved contact surface

Curved contact surfaces shall have a radius R **(Fig. 5.9)**, of not less than 0.5 x di or 100 mm, whichever is the greater.

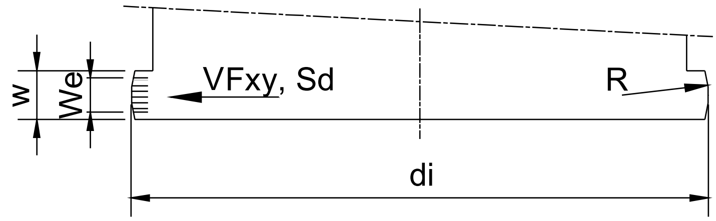


Fig. 5.9 Details of Curved Piston Contact Face

They shall be verified, so that

$V_{sd} \leq V_{Rd}$ Where:

$$V_{Rd} = \frac{15 \times f_u^2 \times R \times di}{E_S \times \gamma_m^2}$$

$$w_e = 3.04\sqrt{\frac{1.5 \times V_{Fxy,Sd} \times R}{E_S \times di}} \text{ and } w_e + \theta \times di \leq w$$

R = radius of curvature of the curved contact surface in mm

w_e = effective contact width

θ = design rotation

E_s = design modulus of elasticity of steel in MPa

d_i = inner diameter of pot in mm

f_u = ultimate tensile strength of the steel material of piston or cylinder, whichever is lower, in MPa

γ_m = 1.1 for cast steel

= 1.0 for rolled steel

NOTE 1: The ability of curved surfaces and plates to withstand deformation under load is dependent upon the hardness of the material from which they are made. There is not a direct relationship between hardness and yield stress of steel but there is relationship between hardness and ultimate strength. Consequently the above expressions are based on the ultimate strength of the material.

NOTE 2: A force concentration factor 1.5 is included in the factor 15.

5.3.1.5 Additional geometrical conditions for required rotation capacity

For the fundamental combination of action it shall be shown that:

- The edge of the piston/elastomer contact face remains within the cylindrical recess formed by the pot wall around the whole circumference **(Fig. 5.10)**.

- There is no contact between the top of the pot wall and any other metallic component **(Fig. 5.10)**.

The above conditions are satisfied when:

$hc - he - (w - we) \times 0.5 - (\theta \times 0.5 \times di) \geq \delta$

$hp - (hc - he) - (\theta \times 0.5 \times Dp) \geq \delta$

For flat contact surfaces $w_e = w$

Where, δ= 0.01 × *di* or 3 mm whichever is greater, but not exceeding 10 mm. **(Fig. 5.10)**.

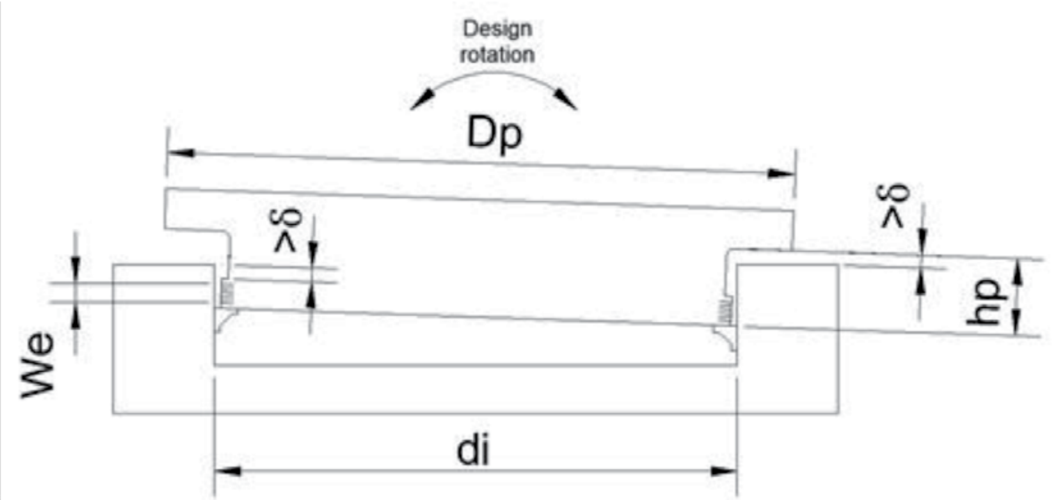


Fig. 5.10 Geometrical Conditions for Rotation

5.3.1.6 For sliding components, stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges. This welding is, however, not to be considered as structural welding. The stainless sheet may also be attached to its backing plate by screwing or riveting but the thickness of the stainless steel sheet shall be at least 2.5 mm in that case. When attaching the stainless steel sheet by screwing or riveting, corrosion resistant fasteners compatible with the stainless 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 PTFE sheet. Care shall be taken to ensure that the stainless steel sheet is fully in contact with the backing plate over the area which will be in contact with the PTFE sheet. The stainless steel surface shall always overlap the sliding material even when the extreme movement occurs.

5.3.1.7 Minimum required thickness of stainless steel is 1.5 mm when the stainless steel is attached by continuous fillet welding. When the stainless sheet is attached to its backing plate by screwing or riveting, the thickness of the stainless steel sheet shall be at least 2.5 mm.

5.3.1.8 Guides shall be designed in accordance with Clause 5.3.5.

5.3.1.9 Anchoring arrangement shall be designed in accordance with Clause 5.3.6.

5.3.2 *Particular recommendations for design of sliding assemblies*

5.3.2.1 PTFE is commonly used as plane sliding element at the interface capable to cater for translational movements. UHMWPE (if supported by independent certification like ETA / FHWA / similar certifying authority) can also be provided as may be required. Sliding assemblies should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding. To accommodate rotation about an axis in the plane of sliding additional arrangement shall be provided e.g. sliding assemblies may be combined with other types of bearings like elastomeric bearings, metallic rocker bearings, Pot bearings etc.

5.3.2.2 Pre-setting of top plate may be allowed, if necessary, while dimensioning it.

5.3.2.3 Sliding assemblies shall preferably have the stainless steel sliding sheet positioned above the PTFE or UHMWPE, so that the sliding surfaces are kept clean.

5.3.2.4 Surfaces mating with PTFE or UHMWPE shall always be made of stainless steel. The mating stainless steel surface shall always overlap the PTFE or UHMWPE even when the extreme movement occurs.

5.3.2.5 Load distribution through the bearing components and the adjacent structures shall be calculated considering the effective contact area after one vertical to one horizontal (1V:1H) of dispersion from confined PTFE / UHMWPE sheets. Effect of eccentricities shall be applied as per **Annexure B.**

5.3.3 Particular recommendations for design of Pin Bearing

5.3.3.1 For Pin bearings the pin shall be designed to withstand the design horizontal force considering the effect of coexisting design rotation. The diameter of pin shall in no case be less than 150 mm. The inner diameter of the cylinder shall be in accordance with the tolerance of fit specified in Clause 6.1.4.3.

5.3.3.2 The mating interface of pin and cylinder shall be designed to withstand the design horizontal force and suitably detailed to facilitate rotational movement.

5.3.3.3 The effective curved contact width of the pin, w_e, shall be designed and detailed as per Clause 5.3.1.4.2.

5.3.3.4 The minimum theoretical clearance between the top edge of cylinder and the bottom edge of pin at design rotation shall not be less than δ, where, δ = 0.01 x di or 3 mm whichever is greater, but not exceeding 10 mm (refer Clause 5.3.1.5).

5.3.3.5 Anchoring arrangement shall be designed in accordance with Clause 5.3.6.

5.3.3.6 The resultant of the coexisting moments produced due to design horizontal force and that induced due to resistance to rotation, if any, shall not exceed the moment of resistance of the group of anchors. The moment of resistance of the group of anchors shall preferably be determined considering the position of the neutral axis by an appropriate method with the basic assumption that plane section, normal to axis, remains plane after bending and the limiting strains in ULS condition. For determining moment of resistance at concrete interface, design properties of concrete shall be considered as per provisions of IRC: 112.

In absence of a proper evaluation of position of neutral axis, the same should be considered along the centreline of the anchor(s) located at the edge of the group and parallel to the axis about which the resultant moment acts. **(Fig. 5.11)**.

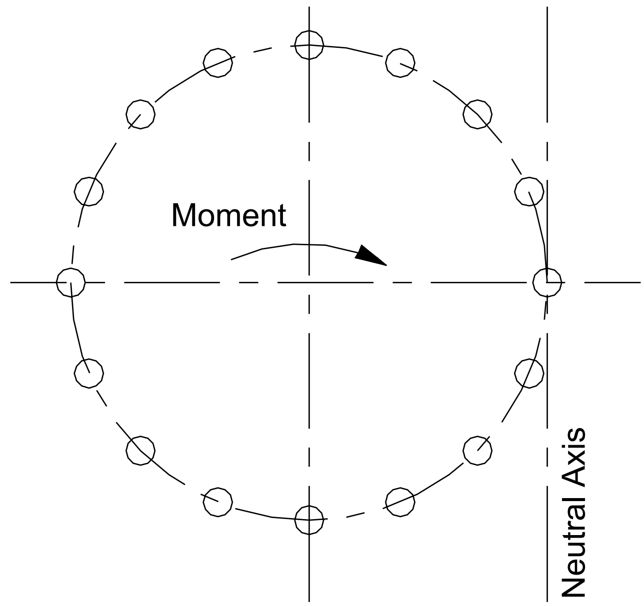


Fig. 5.11 Distribution of forces on bolt/screw/stud group

5.3.3.7 Resistance of group of anchors in shear due to design horizontal force and in tension due to the resultant moment shall be checked as per Clause 5.3.3.6 and **Annexure D** / **Annexure F** as applicable. If the shear and tension are transferred through the same anchors, the combined effect shall also be checked as per **Annexure D** / **Annexure F** as applicable.

5.3.3.8 The thickness of the plates of the Pin bearing through which it is connected to the structure shall be determined considering the effect of maximum tensile force that may occur on any anchor due to resultant moment.

5.3.3.9 The dimensions of the cylinder wall shall be determined using expressions given in Clause 5.3.1.2.3 to 5.3.1.2.8.

5.3.3.10 Minimum thickness of cylinder base shall not be less than 2.5% of the inner diameter of the cylinder. Minimum thickness of any steel component or part thereof shall in no case be less than 16 mm.

5.3.4 Particular recommendations for design of Metallic Guide bearings

5.3.4.1 Metallic Guide bearings shall be provided to resist horizontal force along the direction perpendicular to the direction along which it allows movement. Metallic Guide bearings should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding unless additional rotating device is introduced to accommodate rotation.

5.3.4.2 Sliding interface shall always consist of stainless steel sliding on sliding material defined in Clause 5.2.4. The coefficient of friction at the sliding interface shall be in accordance with **Table 5.5.** The mating stainless steel surface shall always overlap the sliding material even when the extreme movement occurs.

5.3.4.3 Minimum thickness of any steel component or part thereof shall in no case be less than 2.5% of the largest plan dimension (diameter or diagonal) or 16 mm, whichever is higher.

5.3.4.4 The minimum theoretical vertical clearance between the sliding components at design rotation shall not be less than 5 mm.

5.3.4.5 Anchoring arrangement shall be designed in accordance with Clause 5.3.6.

5.3.4.6 The resultant of the coexisting moments produced due to design horizontal force and that induced due to resistance to rotation, if any, shall not exceed the moment of resistance of the group of anchors. The moment of resistance of the group of anchors shall preferably be determined considering the position of the neutral axis by an appropriate method with the basic assumption that that plane section, normal to axis, remains plane after bending and the limiting strains in ULS condition. For determining moment of resistance at concrete interface, design properties of concrete shall be considered as per provisions of IRC: 112.

In absence of a proper evaluation of position of neutral axis, the same should be considered along the centreline of the anchor(s) located at the edge of the group and parallel to the axis about which the resultant moment acts.

5.3.4.7 Resistance of group of anchors in shear due to design horizontal force and in tension due to the resultant moment shall be checked as per Clause 5.3.4.6 and **Annexure D** / **Annexure F** as applicable. If the shear and tension are transferred through the same anchors, the combined effect shall also be checked as per **Annexure D** / **Annexure F** as applicable.

5.3.4.8 The thickness of the plates of the Guide bearing through which it is connected to the structure shall be determined considering the effect of maximum tensile force that may occur on any anchor due to resultant moment.

5.3.4.9 Components of the Metallic Guide bearing shall be checked for bending, shear and combined resistance due to the effect of design horizontal force.

5.3.4.10 Cantilever vertical projection of metallic guide bearings shall be checked as per **Annexure C**.

5.3.5 Design of guides for Pot bearings with Sliding assemblies

5.3.5.1 Sliding surfaces for guides of Pot bearings with sliding assemblies shall be made of stainless steel sliding on either confined PTFE or UHMWPE or Composite Material (CM1). The coefficient of friction at the sliding interface of guides shall be considered as per **Table 5.5**.

5.3.5.2 For characteristics strength of sliding materials, refer **Table 5.4**

5.3.5.3 Cantilever vertical projection of guide of pot bearings shall be checked as per **Annexure C**.

5.3.5.4 Guides shall either be in the form of one guide bar located centrally on the piston of Pot bearing / fixed plate of sliding assembly or two guide bars attached sidewise to the sliding plate.

5.3.5.5 Guides shall be monolithic or welded (refer Clause 6.2.1) to the component to which it is connected. The thickness of the component to which the guide is connected shall in no case be less than the thickness of the guide, measured along the direction of horizontal force acting on the guide.

5.3.5.6 For central guides the thickness of the portion of sliding plate recessed to accommodate guide shall not be less than 0.5 times the thickness of the sliding plate or 0.3 times the width of the recess or 12 mm, whichever is higher. **(Fig. 5.12)**.

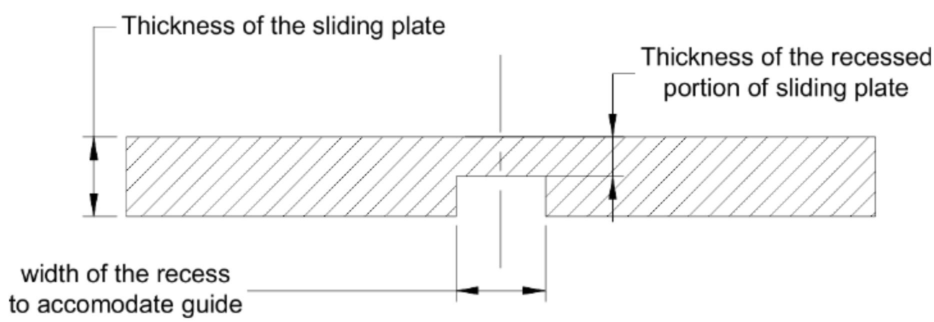


Fig. 5.12 Recess in Sliding Plate for Central Guide

5.3.5.7 For central guides the vertical clearance between the guide and the recessed sliding plate shall not be less than 0.2 percent of the length of the recess or 3 mm, whichever is higher.

5.3.6 Design of anchoring arrangement

5.3.6.1 Bearings should be designed and detailed to make it replaceable with minimum lifting of the superstructure.

5.3.6.2 *Design of fasteners:*

5.3.6.2.1 Bolts of property class as required to satisfy the design requirement in **Annexure D** shall be used for positive anchoring of the bearings with the adjoining structures. The diameter, grade and number of the anchor bolts shall be so chosen such that it satisfy the below expressions:

Resistance in Shear:

$V_{xy,sd} \leq V_{Rd}$

Where,

$$V_{Rd} = \frac{\mu_k}{\gamma_\mu} \times N_{Sd,min} + V_{Pd}$$

V_{pd} = $n \times F_{v,Rd}$

Where,

$V_{xy,sd}$ = Design horizontal force at ULS

V_{Rd} = Total resistance to force that including the anchorage strength and frictional resistance

V_{pd} = Design value of anchorage resistance in Shear

$N_{Sd,min}$ = Minimum vertical load on the bearing in ULS coexisting with $V_{xy,Sd}$

μ_k = characteristic value of friction coefficient between bearing and adjacent structure

= 0.4 for steel on steel

= 0.6 for steel on concrete

γ_μ = Partial safety factor for friction

= 2 for steel on steel

= 1.2 for steel on concrete

n = Number of bolts

$F_{v,Rd}$ = Design shear resistance of single anchor as per **Annexure D**.

In case of dynamically loaded structures where extreme load fluctuations can occur e.g. railway bridges or for structures in high seismic zones (Zones IV and V), contribution due to friction shall not be taken into consideration while designing the anchorage i.e. μ_k=0

5.3.6.2.2 The edge distance for bolt/screw shall not be less than 1.5 times the diameter of hole and the centre to centre distance shall not be less than 3 times the diameter of hole.

5.3.6.2.3 When fasteners (bolts / screws) are not fastened using compatible class of nut but fastened inside tapped threaded holes in steel housing, the minimum fastening thread length shall be as per **Table 5.6**

Table 5.6 Minimum Fastening Thread Length of Bolts / Screws Inside Plate

Material of steel housing	Class of Bolts / Screws of Nominal Diameter of 'd'		
	4.6	**8.8**	**10.9**
E250	1.0d	1.5d	1.8d
E350	0.8d	1.2d	1.5d

5.3.6.2.4 Slip critical / friction type joints may be designed as per IS: 4000

5.3.6.2.5 For temporary fasteners the above stipulations may be relaxed.

5.3.6.3 Design of shear studs

5.3.6.3.1 Shear Stud Connectors – resistance in shear

Concrete Inserts when adopted in the form of Headed Shear Stud shall be minimum 16 mm and maximum 25 mm in diameter. Also the nominal length of the stud shall be at least 3 times the stud diameter in any case. Headed Shear Studs should be welded as per Arc Stud Welding Method in compliance with ISO 14555 and ISO 13918.

The design shear resistance of the headed studs embedded inside the concrete as well design tension resistance, where applicable, shall meet or exceed the total shear force as per the expression below:

$V_{xy,sd} \leq V_{Rd}$

Where,

$$V_{Rd} = \frac{\mu_k}{\gamma_\mu} \times N_{Sd,min} + V_{P,Rd}$$

$V_{p,Rd}$ = $n_s \times P_{Rd}$, where

$V_{xy,sd}$ = Design horizontal force at ULS

V_{Rd} = Total resistance to force that including the anchorage strength and frictional resistance

$V_{P,Rd}$ = Design value of anchorage resistance in Shear

$N_{sd,min}$ = Minimum vertical load on the bearing in ULS coexisting with $V_{xy,Sd}$

μ_k = characteristic value of friction coefficient between bearing and adjacent structure

= 0.6 for steel on concrete

γ_μ = Partial safety factor for friction

= 1.2 for steel on concrete

n_s = Number of shear studs

P_{Rd} = Design shear resistance of single shear stud as per **Annexure F**.

In case of dynamically loaded structures where extreme load fluctuations can occur e.g. railway bridges, structures in high seismic zones (Zones IV and V), contribution due to friction shall not be taken into consideration while designing the anchorage i.e. $\mu k = 0$

Where headed stud connectors are subjected to direct tensile force in addition to shear, the design tensile force per stud F_{ten} should be calculated. If $F_{ten} \leq 0.1\ P_{Rd}$, the tensile force may be neglected. Otherwise, special provision shall be made separately to cater for the tension force on the anchorage.

5.3.6.3.2 Headed shear studs shall be spaced at a centre to centre distance of minimum 5 times the diameter of studs along direction of force and 2.5 times in other direction.

5.3.6.4 Design of anchor sleeves in concrete

5.3.6.4.1 The diameter of the anchor sleeves shall in no case be less than twice the nominal diameter of bolts/screws **(Fig. 5.13).** Length of sleeve shall in no case be greater than five times its diameter.

5.3.6.4.2 The resistance of concrete adjacent to the anchor sleeve, calculated as per the following expression, shall be greater than or equal to the design resistance in shear of single bolt / screw calculated as per **Annexure D**.

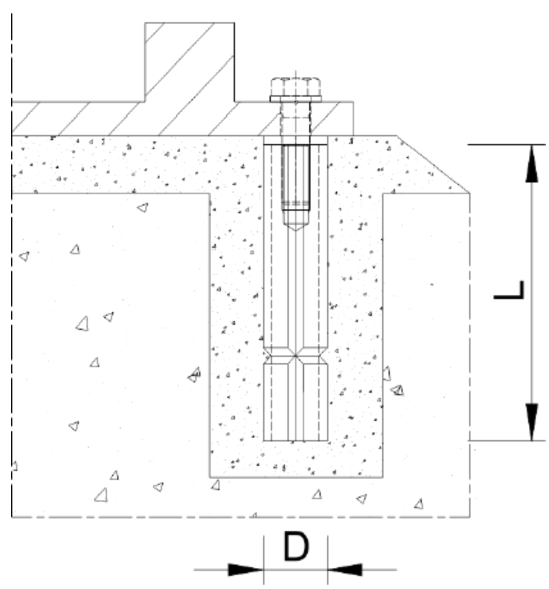


Fig. 5.13 Typical Arrangement of Anchor Sleeves

$F_{Rdu} = D \times L \times \frac{f_{cd}}{\sqrt{3}}$

F_{Rdu} = resistance offered by concrete in ULS

f_{cd}= Permissible direct compressive strength of concrete, calculated as:

$$f_{cd} = \frac{0.67 \times f_{ck}}{1.5}$$

5.3.6.5 *Tension anchors, if needed, shall be designed as per ACI 318M or CEN/TS 1992-4-1.*

6 MANUFACTURE

6.1 Manufacturing Tolerances

6.1.1 The overall dimensions of any assembled bearing or component thereof shall not exceed the following tolerance limits given in **Table 6.1**

Table 6.1 Tolerance Limits

Plan dimension of assembled bearing	:	-0 mm to +5 mm or 0.5 percent of plan dimension (diameter or diagonal), whichever is higher
Overall height of assembled bearing	:	-0 mm to +5 mm or 3 percent of overall height, whichever is higher
Parallelism of top surface of assembled bearing w.r.t. the bottom surface as datum	:	1 in 200
Height of confined elastomeric pressure pad	:	-0 mm to +2.5 mm for di ≤ 750 mm and -0 to +di/300 for 750 mm < di < 1500 mm
Thickness of any machined steel component	:	-0 to +1 mm
Centre to centre of anchor bolt holes	:	-1 mm to +1 mm
Stainless steel sliding surface	:	
a) Flatness		0.0003L or 0.2 mm whichever is higher, where L = length in direction of major movement
b) Surface finish		$R_z \leq 1$ µm as per ISO 4287

6.1.2 Flatness of backing plate in contact with sliding material shall be 0.0003 d or 0.2 mm, whichever is higher, here d is diameter or diagonal of the sliding material.

6.1.3 The shoulders of the recess of sliding material shall be sharp and square to restrict the flow of sliding material. The radius at the root of recess shall not exceed 1 mm.

The depth of confining recess shall be as per **Table 5.3**.

In principle the sliding material shall fit the recess without clearance. Intermittent gap between edge of sliding material and the recess shall not exceed the values given in **Table 6.2**

Table 6.2 Tolerance on Fit of Sliding Surface in the Recess

Dimension L (mm)	Gap (mm)
75 - 500	0.5
501 - 1000	1.0
1001 - 1500	1.5

6.1.4 Tolerance of fit between different components of bearings shall be as follows:

6.1.4.1 The maximum diametrical clearance between the pot and piston shall not exceed 1 mm.

6.1.4.2 After filling up Elastomeric Pad inside the POT bearing the peripheral gap shall not exceed 0.2 percent of the diameter of the pad or 1.0 mm whichever is higher.

6.1.4.3 For Pin bearings the diametrical clearance between the pin and cylinder shall be +1.0 mm to +2.0 mm.

6.1.4.4 The tolerance of fit between sliding material of guide(s) and adjacent stainless steel surface shall be +1 mm to +4 mm.

6.1.4.5 Surface Roughness

6.1.4.5.1 Surface Roughness Rz of the inner cylindrical surface of the pot in contact with the elastomer shall not exceed 6.3 μm.

6.1.4.5.2 Surface Roughness Rz of the plane surface of pot or piston in contact with the elastomer shall not exceed 25 μm.

6.2 Manufacturing Method

6.2.1 The main components of bearing shall be made as a single monolithic body. However, in case welding is to be used for fabrication of main components, then the same shall be allowed only if the manufacturer is having ISO 3834-2 certification along with EN 1090 or AISC certification.

6.2.2 For sliding components stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges in such a fashion so as to ensure flatness of the stainless steel sheet throughout its service life and avoid entrapment of air and prevent ingress of moisture at the interface. The backing plate shall extend beyond the edges of the stainless steel sheet to accommodate the weld and the weld should not protrude above the stainless steel sheet. The heat affected zone (HAZ) of the stainless steel sheet shall be protected with corrosion protection measure.

6.2.3 PTFE/ UHMWPE shall be secured and confined in the recesses preferably by shrinking fit method only for confinement. Glue may be used for vertical surfaces e.g. Guide / Guide bearing. For large PTFE/UHMWPE sheets subdivided into parts, each individual part shall be confined into separate recess.

6.2.4 For brass sealing ring type of internal seal, the configuration of the sealing system shall be as per **Table 6.3**.

Rings with a minimum cross-section of 10 mm X 2 mm may have slits 7 mm deep ´ 0,5 mm wide spaced at 5 mm around the inner diameter to facilitate forming. Rings with a smaller cross-section shall not have slits.

Table 6.3 Allowable Solid Brass Sealing Ring Configurations

Diameter di mm	Minimum cross section mm	Slits	Number of rings
≤ 330	6 X 1,5	Not permitted	2
> 330 < 715	10 X 1.5	Not permitted	2
= 715 <1500	10 X 1.5	Not permitted	3
< 1500	10 X 2	7 mm X 0,5 mm 5 mm spacing	**3**

6.2.5 For POM sealing chain type of internal seal, the sealing chain, made of individual interlocking elements, shall be moulded as an integral part of the elastomeric pressure pad during the vulcanisation process for proper functioning. Width and height of the individual elements shall be:

a) elastomer diameter *di* ≤ 550 mm : 10 mm ± 0.5 mm;

b) elastomer diameter *di* > 550 mm: 15 mm ± 1.0 mm.

6.2.6 The carbon filled PTFE seal shall be completely recessed into the elastomeric pad.

6.2.7 Stainless Steel seal shall be made from stainless steel strip formed into an equal or unequal angle section inserted between the elastomeric pad and the pot wall. The leg length and thickness of the section shall meet the following.

a) with notches:

where diameter *di* ≤ 700 mm - leg length 5 mm to 10 mm, thickness 1 mm minimum; where diameter *di* > 700 mm mm leg length 15 mm to 17 mm, thickness 1,5 mm minimum; the minimum overlap of the ring ends shall be 20 mm; where the thickness > 1 mm, the ends shall be reduced in thickness at the overlap position.

b) without notches:

minimum leg length 3 mm; minimum thickness 1 mm; minimum overlap 5 mm; where the thickness > 1 mm, the ends shall be reduced in thickness at the overlap position.

6.2.8 Any pre-setting of sliding element, if required, shall preferably be done in the manufacturer's workshop before dispatch.

6.2.9 Bearings shall be provided with temporary transportation clamps to avoid separation of parts during transportation and erection.

6.2.10 All welding shall be done by qualified welder on the basis of applicable WPS and the same shall be preapproved by certified welding inspector subject to qualification tests. All welding processes applied will be as per IS: 816 & IS 9595 with electrode or filler material used as per IS: 814 or IS: 1278 or any other relevant applicable standards respectively. The approved welder qualification record and relevant WPS & WPQR shall be made available during inspection.

6.2.11 Headed Shear Studs should be welded as per Arc Stud Welding Method in compliance with ISO 14555 and ISO 13918.

6.2.12 Movement indicators may be provided for bearing with sliding assembly to facilitate routine inspection during service period.

6.2.13 All sharp edges, including edge of bolt holes (except housing recess of sliding material) shall be made blunt by chamfering.

6.3 Finishing

6.3.1 *Corrosion Protection*

6.3.1.1 All non-working exposed surfaces, including 50 mm (min.) return on surfaces to be in contact with concrete / steel shall be treated with full corrosion protection system as per ISO 12944. Extremely severe zone as marked in Corrosion Map of India shall be considered as C5M/C5I category, severe zone shall be considered as C4 category. All other zones of Corrosion Map of India shall be considered as C3 category.

6.3.1.2 The surfaces mentioned above shall be suitably prepared by sand / grit blasting to cleanliness standard of Sa 2½ (minimum) as per ISO 8501-1. For thermal spraying of zinc, surfaces cleanliness standard should be Sa 3.

6.3.1.3 Subsequent to surface preparation as stated above, all non-working exposed surfaces shall be given suitable protective coat by painting or by thermal spraying of zinc. Thermally sprayed surface should be covered with at least one coat of barrier coating. The protective coating shall be designed as per ISO 12944-5 for high durability with life more than 15 years. Total dry film thickness for any corrosivity category shall not be less than the minimum DFT value specified in **Table 6.4**.

Table 6.4 Minimum DFT as per Corrosivity Category

Corrosivity Category	Min. DFT
C5M/C5I	320 μm
C4	240 μm
C3	160 μm

6.3.1.4 Application of protective coating shall comprise with sacrificial primer coating and barrier coating followed by a finish coat comprised of material mainly used for UV protection against degradation of paint system.

Most commonly used coating specification is as given below:

- Zinc rich epoxy primer or thermally sprayed zinc or zinc rich ethyl silicate primer as sacrificial primer coat
- Epoxy MIO / Epoxy or equivalent as intermediate coat
- Polyurethane / Epoxy as finish coat

6.3.1.5 Bearing components to be in contact with concrete structure beyond return zone of full corrosion protection shall be given a nominal sacrificial coat as mentioned in Clause 6.3.1.4 before despatch to prevent corrosion during transportation and storage at site. The protective coating shall not affect the bond between the bearing component and the concrete.

6.3.1.6 Bearing component in contact with steel structure or any steel to steel contact surface of the bearing shall be provided with a coat of Zinc Rich Ethyl Silicate primer beyond return zone of full corrosion protection system.

6.3.1.7 Surface of backing plates in contact with sliding material shall be provided with a nominal sacrificial coat before fixing of sliding material.

6.3.1.8 For corrosivity category C4 and above, all fasteners shall be either hot dip galvanized to minimum 40 μm or applied with equivalent Dacromet coating. For all other corrosivity category electrogalvanized coating of 15 μm may be adopted.

6.3.2 Appropriate silicon grease shall be applied at the sliding material – stainless steel interface of bearing.

6.3.3 Appropriate silicon grease shall be applied to lubricate the pressure pad which must not affect the material of confined elastomer.

7 ACCEPTANCE SPECIFICATION

7.1 General

7.1.1 Bearings shall be manufactured to high standards both in terms of material quality and workmanship. The manufacturer shall have requisite load test and NDT facilities required for process and acceptance control tests installed at his plant. The test facilities and their operation shall be open for inspection. For confirmatory tests on raw materials, tests shall be conducted at in-house facility of the manufacturer or at NABL accredited laboratory.

7.1.2 As a prerequisite, the bearing manufacturer shall be certified in accordance with ISO 9001. In addition, the following requirements shall be fulfilled by the manufacturer.

7.1.2.1 Fabricated construction of component is allowed only if the manufacturer is having ISO 3834-2 certification along with EN 1090 or AISC certification, all welders should be qualified and duly certified in accordance with ISO 9606 or IS: 7318 or AWS D1.5. The manufacturer should have on-board qualified welding inspector holding CWI / CSWIP / IWE / IWT qualification.

7.1.2.2 NDT Level II experts for visual test, liquid penetration test and ultrasonic test should be available onboard with the manufacturer.

7.1.2.3 On-board availability of NACE Certified Coating Inspector (Level 1) and certified spray metalizer are also preferred.

7.1.3 All tests on raw materials and finished bearings shall be carried out as per procedures described in this section. All the test reports duly certified by the inspector shall be furnished by the manufacturer at the time of despatch of the bearing.

7.1.4 Acceptance testing shall commence with the prior submittal of testing program in form of Inspection and Test Plan (ITP) prepared by the manufacturer and approved by concerned authority, to the inspector.

7.2 Inspection Procedure

7.2.1 *Inspection and testing of the bearings shall require the following two types of tests:*

7.2.1.1 Type test

Type test, which includes inspection and testing as per Clauses 7.4.2 & 7.4.3 shall be carried out on at least one bearings of each type and load capacity selected at random. The inspector may also carry out random tests as per Clause 7.4.1 as per approved Inspection and Test Plan on raw material samples drawn by the manufacturer for such tests. In such cases the inspector may be present for identification and marking of the sample when it is drawn.

7.2.1.2 *Routine test*

Routine test, which includes inspection and testing as per Clauses 7.4.1, 7.4.2 & 7.4.3 shall be carried out by the manufacturer for the bearings of each lot under acceptance.

7.2.2 The various inspection and tests may be classified into the following categories:

– Raw materials inspection.
– Inspection and testing of finished bearings.
– Process inspection.

7.3 Quality Control Report

A detailed quality control report of routine test shall be furnished by the manufacturer to the inspector, for each lot of bearing offered for inspection.

7.4 Detail of tests

7.4.1 *Tests on raw materials*

7.4.1.1 Mill Test Certificates (MTC) shall be furnished by the manufacturer. In absence of MTC, test on raw materials as per relevant material standards shall be carried out by the manufacturer and Test Report shall be furnished.

7.4.1.2 The manufacturer should be able to establish the traceability of all major raw material **(Annexure G)** with procurement and consumption record and Mill Test Certificate/ material test report.

7.4.1.3 Mill Test Certificates (MTC) or material test report carried out by manufacturer shall at least include the materials and control parameters described in **Annexure G**

7.4.2 *Process Inspection:*

7.4.2.1 All bearing components shall be checked for dimension control as per manufacturing tolerances specified in Clause 6.1.

7.4.2.2 Tolerance of fit and surface roughness shall be controlled as per Clause 6.1.

7.4.2.3 Major metallic components as specified in **Annexure G,** shall be ultrasonically tested for soundness as per Level: 3 of IS: 9565 prior to use in bearings.

7.4.2.4 All structural welds shall be visually checked for weld size and location as per drawing as well as controlled as per the following tests:

- Visual test (all structural welds)
- Liquid penetration test as per IS: 822 (all structural welds)
- All full penetration butt welds shall be controlled through ultrasonic testing as per IS 4260 / AWS D1.5 / ASME Section VIII

7.4.2.5 Corrosion protection: Corrosion protection measures shall be controlled in accordance with the requirement specified in Clause 6.3.

7.4.3 Inspection of finished bearings

7.4.3.1 All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape or any other discernible superficial defects.

7.4.3.2 All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 6.1.

7.4.3.3 At least one or a pair of bearings (depending on the requirement) of each type and different vertical load capacity selected at random shall be load tested as described below:

7.4.3.3.1 **Proof Load test:** Bearings shall be load tested for a test load equal to 1.5 times the specified design vertical load in SLS condition. Load shall be applied gradually and the test load shall be held for 30 minutes. The load shall then be removed and the bearing shall be dismantled and visually examined as given in Clause 7.4.3.4.

7.4.3.3.2 **Friction test:** For bearings with sliding component, friction test shall be performed to determine static coefficient of friction of properly lubricated sliding interface at constant vertical load equal to the design vertical load in SLS condition. Test assembly may comprise of a pair of bearing or a bearing and dummy sliding interface made of similar material. The horizontal load shall be applied till sliding occurs. Coefficient of friction (μ) shall be determined as the ratio of Horizontal Load at which sliding occurs divided by 2 times the applied Vertical Load (two times the vertical load in denominator represents two sliding interface due to use of a pair of bearing or a bearing with dummy sliding interface). The value of coefficient of friction shall not exceed the value specified in Clause 5.2.4.6.

7.4.3.3.3 **Rotation test:** Rotation test shall be performed on Pot bearing with properly lubricated elastomeric pressure pad under a constant vertical load equal to design load in SLS condition and for rotation value of 0.02 radian or design rotation, whichever is higher. Rotation may be applied using tapered plate having slope of test rotation value.

7.4.3.4 The test bearing(s) shall be visually examined both during and after the test. Any resultant visual defects such as physical destruction, cold flow of sliding material with reduction of projected height beyond 0.5 mm, damage of internal seal and/or extrusion of the confined elastomeric pressure pad for Pot bearing, defects / cracks at metal-to-metal contact surfaces etc. shall cause rejection.

7.4.3.5 Proof Load test, Friction Test and Rotation Test are normally not applicable for Pin and Metallic Guide Bearings. In case of any special requirement of load test for Pin or Metallic Guide Bearing, the test specification, requisite test facility and fixing arrangement of the bearing in test rig shall be pre-discussed and agreed upon with the manufacturer and included in the approved ITP.

7.4.4 In case of any evidence of process of acceptance control testing being deemed unsatisfactory by the inspector, complete bearing or particular component(s) of the entire lot may be rejected depending on the cause of rejection i.e. if the raw material testing result of any material is unsatisfactory the component(s) involving that material shall be rejected for the entire lot but if a finished bearing fails in load test the complete bearing shall be rejected and all the bearings of that type and load capacity shall be load tested before acceptance. If the result of process inspection is unsatisfactory, proper rectification measures should be adopted and the acceptance test(s) shall be repeated.

8 CERTIFICATION & MARKING

8.1 Certification and marking should be done as follows:

8.1.1 Bearings should be transported to bridge site after final acceptance by the inspector/ inspection agency appointed by the concerned authority and shall be accompanied by an authenticated copy of the certificate to that effect.

8.1.2 It is desirable to list the required bearing characteristics in a consistent and comprehensive manner in an information card duly certified by the manufacturer and append the same with the inspection certificate.

8.1.3 All bearings shall have suitable index markings made of indelible ink or flexible paint, which if practicable shall be visible after installation, identifying the following information:

- Name of manufacturer
- Month and year of manufacture
- Bearing designation
- Type of bearing
- Load and movement capacity
- Centreline markings to facilitate installation
- Direction of major and minor movement, if any
- Pre-set, if any

9 INSTALLATION

9.1 General

9.1.1 Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. Bearings shall be so located as to avoid accumulation of dirt and debris likely to interfere with their performance and the structure so detailed that water is prevented from reaching the bearings. Proper installation of bearing is of utmost importance to ensure proper functioning of bearing and its durability. Poor installation may not only damage a high quality bearing but also may cause damage, instability and collapse of structures.

9.1.2 In order that moving surfaces are not contaminated, bearings should not normally be dismantled after leaving the manufacture's workshop but if for any reason they are, then this should only be done under expert supervision and the manufacturer's assistance should be sought.

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

9.1.4 Suitable temporary supporting arrangements under bearing base plates should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure, if necessary. Such temporary supports, if provided, should be compressible under design loading or removed once the bedding material has reached the required strength. Any voids left as a consequence of their removal should be made good using the same type of bedding material. Steel folding wedges and rubber pads are suitable for such temporary supports under bearing base plates.

9.1.5 A bearing will only work properly if the connected parts of the structure are rigid enough. This is usually achievable for massive concrete structure with properly done bedding (Clause 9.2). But in case of steel superstructure an increased level of stiffness with adequate stiffeners to avoid local bending / buckling of bottom girder seating above the bearing is absolutely necessary.

9.1.6 Correct location and orientation of the bearing with respect to the structures is of immense importance Mixing up in location or orientation may cause severe structural instability during construction and service.

9.1.7 Stability of structure or structural component (girder) over bearing shall be ensured at every stage of construction. Adequate external support/arrangement may be necessary to ensure stability of superstructures or its part at every stage of construction and till overall stability of the structure is achieved.

9.2 Bedding

9.2.1 Bearing shall not be placed directly on matured concrete surface without use of appropriate bedding material.

9.2.2 The choice of bedding materials is influenced by the method of installation of the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding material, consideration should therefore be given to various factors like type of bearing, size of bearing, loading on bearing, construction sequence and timing, early loading, friction requirements, access around the bearing, thickness of material required, design and condition of surface in the bearing area, shrinkage of the bedding material etc. as appropriate.

9.2.3 The thickness of the bedding material should be made as less as possible maintaining the requirement of workability and strength.

9.2.4 It is essential that the composition and workability of the bedding material be specified with the above factors in mind. In some cases it may be necessary to carry out trials to ascertain the most suitable material. Commonly used materials are non-shrink, free flow, cementitious or chemical resin mortar and grout.

9.2.5 To ensure even loading on bearings and the supporting structures, it is essential that any bedding material whether above and below the bearing, extend over the whole area of the bearing. Improper application of bedding material, below and above the bearing, i.e. voids, gaps, impurity etc. may attribute to failure of the bearing irrespective of the quality of the product.

9.2.6 Bearings shall be bedded over their whole area. After installation there shall be no voids or hard spots. The bedding material shall be capable of transmitting the applied load to the structure without damage. Surfaces to receive bedding mortar shall be suitably prepared to a state compatible with the mortar chosen. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

9.3 Fixing of Bearing

9.3.1 To cater for vibration and accidental impact, some anchorage should be provided. Anchorage should be accurately set into recesses cast into the structure using templates and the remaining voids in the recesses should be filled with material capable of withstanding the loads involved.

9.3.2 Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Finally voids beneath the bearings should be completely filled with bedding material using the appropriate method.

9.3.3 Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure or bottom of superstructure to the correct level and location. It is not advisable to fix foundation anchorages to both substructure and the superstructure simultaneously. This is for the reason of construction tolerances on the span length. Generally recess are provided in the substructure for the anchorages.

9.3.4 If the structure is of steel, the bearings may be bolted or welded directly to it. Proper care shall be taken to ensure that there are no mismatch in the bolt holes of the structure and the bearing. In case of welding care should between to assess and avoid damage of bearing or its components due to heat or distortion.

9.3.5 Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.

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

9.3.7 For bearings supporting precast concrete elements a thin layer of synthetic resin mortar should be used between bearings and precast concrete beams. Bearings shall be bolted to anchor plates or metal bedding plates embedded in precast elements.

9.3.8 For bearing supporting steel elements a machined sole plate shall be used to ensure proper contact.

9.4 Installation Tolerance

9.4.1 The tolerances given in Clause 9.4.2 shall be observed unless otherwise specified.

9.4.2 Bearings shall be located so that their centrelines are within +/- 3 mm of their correct position. The level of a bearing or the mean levels of more than one bearing at any support shall be within a tolerance of +/- 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding +/- 5 mm. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction unless otherwise specified, even under superstructure in gradient.

10 MAINTENANCE

10.1 This section stipulates the requirements for inspection and maintenance of Pot, Sliding, Pin and Metallic Guide bearings during service period.

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

10.1.2 Suitable easy access to the bearing shall be provided for inspection and maintenance. It is advisable to provide adequate maneuvering space all around the bearing. Provision shall be made for jacking up the superstructure so as to allow repair/ replacement of the bearings.

10.1.3 Inspection of bearing at site is required 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 required to be inspected at an interval of one year for the first five years and at an interval of two years thereafter. However the bearings shall also be examined carefully after unusual occurrences like heavy traffic, earthquakes, cyclones and battering from debris in high floods.

10.1.4 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.

10.2 Elements of inspection

10.2.1 *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.

10.2.2 *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.

10.2.3 *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.

10.2.4 *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 affected part
- Wire brush the affected portion to clean of its rust.
- Apply protective coating as per manufacturer's specifications.

10.2.5 *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.

10.3 Results and actions

The results of every inspection has to be recorded in the inspection report and shall be classified in each case into the following types of action:

X No action.

XX Further measurements / long-term monitoring or design analysis needed (e.g. considering extreme temperatures / exposures, variation of loads etc.). Actions to be outlined in a report.

XXX Minor repair works e.g. cleaning, repainting etc.

XXXX Repair or replacement of entire bearings or parts of the bearings. Actions to be outlined in a report.

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.1 Typical Load Data Format:

1	Structure Reference							
2	Bearing Identification mark							
	Type of Bearing							
3	Number Off							
4	Seating Material and characteristic strength	Upper Surface						
		Lower Surface						
5	Design Load (KN)	Serviceability Limit state (SLS)	Vertical	max				
				permanent				
				min				
			Transverse					
			Longitudinal					
		Ultimate Limit state (ULS)	Vertical	max				
				min				
			Transverse					
			Longitudinal					
6	Displacement (mm)	SLS	Irreversible	Transverse				
				Longitudinal				
			Reversible	Transverse				
				Longitudinal				
		ULS	Irreversible	Transverse				
				Longitudinal				
			Reversible	Transverse				
				Longitudinal				

7	Rotation (Radians)	SLS	Irreversible	Transverse				
				Longitudinal				
			Reversible	Transverse				
				Longitudinal				
8	Maximum bearing dimensions (mm), if restricted	Upper Surface	Transverse					
			Longitudinal					
		Lower Surface	Transverse					
			Longitudinal					
		Overall height						
9	Maximum acceptable reaction to rotation under serviceability limit state (kN x m), if restricted			Transverse				
				Longitudinal				
10	Type of fixing required			Upper face				
				Lower face				
11	Corrosivity category (Refer Clause 6.3)							
12	Special requirements (if any)							

ANNEXURE B

B.1 Reduced Area for Eccentric Loading

A_r = $A_{co}\left(1 - 0.75\pi\frac{e}{L}\right)$ for circular loaded area

= A_{co} – 2e x a for rectangular loaded area

A_r = reduced area

A_{co} = loaded area for no eccentricity

L = diameter of circular loaded area

a = dimension of loaded area across eccentricity

b = dimension of loaded area along eccentricity

e = eccentricity and the above formula is only valid if the one of following criteria is met:

$e \leq \frac{L}{8}$ (for circular loaded area)

$e \leq \frac{b}{6}$ (for rectangular loaded area)

NOTE 1: If $e > \frac{L}{8}$ (for circular loaded area) or $\frac{b}{6}$ (for rectangular area), separation of part is expected and in such cases special measure, if applicable, may be taken to avoid separation.

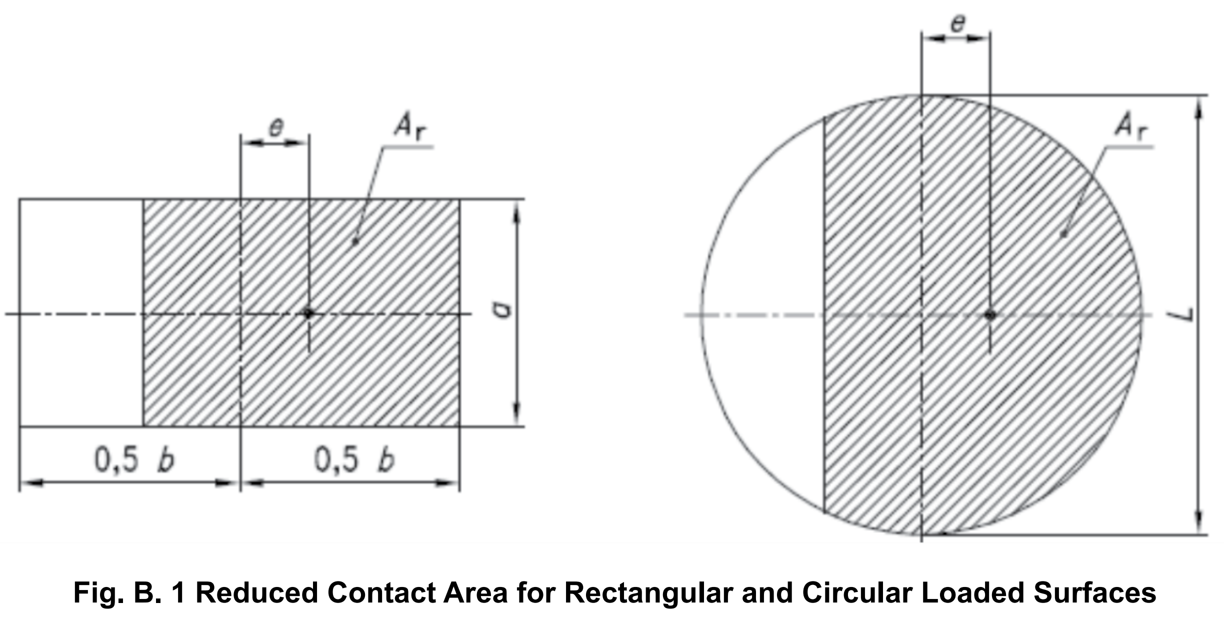
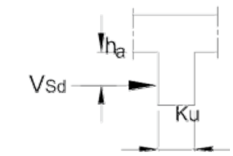
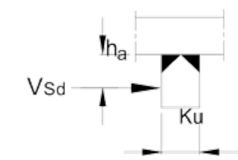
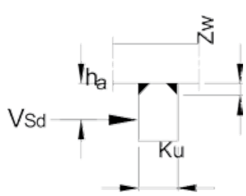
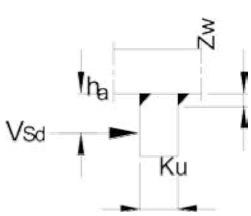
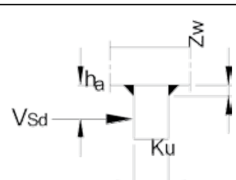


Fig. B. 1 Reduced Contact Area for Rectangular and Circular Loaded Surfaces

ANNEXURE C

C.1 Design Resistance for Guides:

Table C. 1: Types of Guides

a)		Guides monolithic to plate	No weld design
b)		Guides connected by full penetration butt weld	The design resistance of a full penetration butt weld should be taken as equal to the design resistance of the weaker of the parts connected
c)		Guides connected by partial penetration butt weld	$Vw = \frac{V_{Sd}}{2 \times L_{,eff}}$ $Tw = \frac{V_{Sd} \times ha}{\{(ku - 2.Zw) \times L_{,eff}\}}$
d1)		Guides connected by fillet weld	$Vw = \frac{V_{Sd}}{2 \times L_{,eff}}$ $Tw = \frac{V_{Sd} \times ha}{ku \times L_{,eff}}$
d2)			
Vw = Shear force per unit length of weld *Tw* = Tension force per unit length of weld			

C.1.1 Shear resistance:

$V_{Sd} \leq V_{Rd}$, where

V_{Sd} = Horizontal force

$$V_{Rd} = \frac{k_u \times L_{,eff} \times fy}{\sqrt{3} \times \gamma_m}$$

Where,

k_u = Thickness of the guide

$L_{,eff}$ = Effective Length of guide

= L + 2 × h_a or length of the guide, whichever is greater

L = Length of side sliding material

f_y = Yield strength of guide

γ_m = 1.1 for cast steel

= 1.0 for rolled steel

C.1.2 Bending resistance in combination with shear resistance:

$M_{Sd} \leq M_{Rd,}$ where

M_{Sd} = bending moment = $V_{Sd} \times h_a$

M_{Rd} = Reduced bending resistance

$$= \frac{k_u^2 \times L_{,eff} \times f'_y}{\gamma_m}$$

h_a = Height of application of horizontal force on guide

$f'_y = (1 - \rho)\, f_y$

$\rho = 0$, if $V_{sd} \leq 0.5V_{Rd}$

$= \left(\frac{2 \times V_{Sd}}{V_{Rd}} - 1\right)^2$ if $V_{Sd} > 0.5V_{Rd}$

fy = Yield strength of guide

γm = 1.1 for cast steel

= 1.0 for rolled steel

C.1.3 Design of welds for guides:

$F_{w,Ed} \leq F_{w,Rd}$,where,

$F_{w,Ed}$ is the design value of the weld force per unit length $= \sqrt{V_w^2 + T_w^2}$

V_w = shear force per unit length of weld obtained from **Table C.1**

T_w = tension force per unit length of weld obtained from **Table C.1**

$F_{w,Rd}$ = design weld resistance per unit length from **Annexure E.**

ANNEXURE D

D.1 Design Resistance for Individual Fasteners:

Failure Mode	Bolts
Shear resistance per shear plane	$F_{v,Rd} = \frac{\alpha_v \times f_{ub} \times A}{\gamma_{m2}}$ $F_{v,Rd}$ = shear resistance per bolt per shear plane *A* gross cross section of the bolt if shear plane passes through unthreaded portion $A=A_s$ i.e., tensile stress area of the bolt if shear plane passes through the threaded portion f_{ub} = Ultimate Tensile Strength of bolt Where the shear plane passes through the threaded portion of the bolt: - for classes 4.6 and 8.8: α_v = 0.6 - for class 10.9: α_v = 0.5 Where the shear plane passes through the unthreaded portion of the bolt: α_v = 0.6 for any class of bolt
Bearing resistance	$F_{b,Rd} = \frac{1.25 \times f_u \times d \times t}{\gamma_{m2}}$, where, f_u is the ultimate tensile strength of weaker material *d* is the nominal diameter of bolt *t* is the thickness of bearing area
Tension resistance	$F_{t,Rd} = \frac{k_2 \times f_{ub} \times A_s}{\gamma_{m2}}$,Where f_{ub} = Ultimate Tensile Strength of bolt k_2 = 0.63 for countersunk bolt, Otherwise, k_2 = 0.9

Combined shear and tension	$\frac{F_{v,Sd}}{F_{v,Rd}} + \frac{F_{t,Sd}}{1.4 \times F_{t,Rd}} \leq 1.0$, where, $F_{v,sd}$ is the design shear force per bolt per shear plane $F_{t,sd}$ is the design tensile force per bolt

γ_{m2}= 1.25

The bearing resistance $F_{b,Rd}$ for bolts

– In oversized holes is 0.8 times the bearing resistance for bolts in normal holes.

– In slotted holes, where the longitudinal axis of the slotted hole is perpendicular to the direction of the force transfer, is 0.6 times the bearing resistance for bolts in round, normal holes.

For countersunk bolt:

– The bearing resistance $F_{b,Rd}$ should be based on a plate thickness '*t*' equal to the thickness of the connected plate minus half the depth of the countersinking.

ANNEXURE E

E.1 Design Resistance for Fillet Weld

The design resistance of a fillet weld may be assumed to be adequate if, at every point along its length, the resultant of all the forces per unit length transmitted by the weld satisfy the following criterion:

$F_{w,Ed} \leq F_{w,Rd,}$ where:

$F_{w,Ed}$ is the design value of the weld force per unit length; In case of orthogonal forces applied on the weld, it should be derived by vectorial addition of two orthogonal forces applied on the weld.

$F_{w,Rd}$ is the design weld resistance per unit length.

Independent of the orientation of the weld throat plane to the applied force, the design resistance per unit length $F_{w,Rd}$ should be determined from:

$F_{w,Rd} = f_{vw,d}$ x a, where:

$f_{vw,d}$ is the design shear strength of the weld

a is the throat thickness = $\frac{weld\ leg\ size}{\sqrt{2}}$

The design shear strength $f_{vw,d}$ of the weld should be determined from:

$f_{vw,d} = \frac{f_u}{\sqrt{3} \times \beta_w \times \gamma_{m2}}$ where:

f_u is the ultimate tensile strength of the weaker part joined

β_w = 0.8 for E250 grade steel or equivalent

= 0.9 for E350 grade steel or equivalent

γ_{m2}= 1.25

E.2 Design Resistance for Partial Penetration Butt Weld

The design resistance of a partial penetration butt weld may be determined using the method for a fillet weld given in B.1

E.3 Design Resistance for Full Penetration Butt Weld

The design resistance of a full penetration butt weld should be taken as equal to the design resistance of the weaker of the parts connected, provided that the weld is made with a suitable consumable which will produce all-weld tensile specimens having both a minimum yield strength and a minimum tensile strength not less than those specified for the parent metal.

ANNEXURE F

F.1 Design Resistance for Individual Headed Shear Stud:

The shear resistance of a single headed shear stud shall be derived from the lesser value when calculated from the following expressions:

$P_{Rd} = \frac{(0.8fu \times 0.25\pi d^2)}{\gamma_v}$, where $\gamma_v = 1.25$

$= \frac{0.29\ \alpha \times d^2 \sqrt{0.8f_{ck} \times E_{cm}}}{\gamma_v}$, where $\gamma_v = 1.25$

P_{Rd} = Design resistance of single headed stud in shear

fu =Specified min. ultimate tensile strength of the stud material but in no case shall exceed 500 MPa

$\alpha = 0.2\left(\frac{h_{sc}}{d} + 1\right)$ for $3 \leq \frac{h_{sc}}{d} \leq 4$

$= 1$ for $\frac{h_{sc}}{d} > 1$

d = stud diameter

h_{sc} = length of stud including head

E_{cm} = short term static modulus of elasticity of concrete as per IRC: 112

f_{ck} = characteristics compressive strength of 28 day's concrete cube

ANNEXURE G

G.1 Nominal Control Requirements for Raw Materials:

Table G.1: Nominal control requirements for raw materials

Raw Material	Nominal Control Parameters	Frequency
Mild / Rolled steel (Clause 4.1.1)	Chemical Test: - C, Mn, Si, S, P	For each plate/ heat number
	Mechanical Test: - Ultimate Tensile Strength - Yield Stress - % Elongation - Charpy Impact Test at -20°C (for use of bearing in sub-zero condition)	For each plate/ heat number
	Ultrasonic Test for Soundness (as per level 3 of IS: 9565)	Applicable for all plates of thickness > 63mm
Cast Steel (Clause 4.1.2)	Chemical Test: - C, Mn, Si, S, P	For each heat number
	Mechanical Test: - Ultimate Tensile Strength - Yield Stress - % Elongation Charpy Impact Test at -20°C (for use of bearing in sub-zero condition)	For each heat number
	Ultrasonic Test for Soundness (as per level 3 of IS: 9565)	100% (each steel casting)
Forged Steel (Clause 4.1.3)	Chemical Test - C, Mn, Si, S, P	For each heat number
	Mechanical Test: - Ultimate Tensile Strength - Yield Stress - % Elongation	For each heat number
	Ultrasonic Test for Soundness (as per level 3 of IS: 9565)	100% (each steel forging)

Raw Material	Nominal Control Parameters	Frequency
Stainless Steel (Clause 4.1.4)	Chemical Test - C, Mn, Ni, Cr, Si, S, Mo & P	For each heat number / per lot of procurement of each thickness
	Mechanical Test: - Hardness (EN 10088-1)	For each heat number / per lot of procurement of each thickness
Unfilled PTFE (Table 4.1)	Mechanical Test: - Mass density - Tensile strength - Elongation at break - Ball hardness	Each production batch
UHMWPE	UHMWPE – Valid approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading international Specifications in the name of Bearing Manufacturer	-
Elastomeric Pad (Table 4.3)	Mechanical Test: - Tensile strength - Elongation - Hardness	Each production batch
	- Tear resistance - Compression Set - Accelerated Ageing	Once for the entire supply order
	- Ozone	Ozone test may be conducted on the compound by the manufacturer at least once in each quarter
Fasteners (Clause 4.8)	Chemical Properties	Each size per procurement lot
	Mechanical Properties	Each size per procurement lot
Shear Stud (Clause 4.9)	Chemical Test - C, Mn, Si, S, P	Each size per procurement lot
	Mechanical Test - UTS - Yield Stress - % Elongation	Each size per procurement lot

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)

Notification No. 29

Amendment No.2/IRC:83 (Part III)/December, 2019 (Effective from 1st February, 2020)

To

IRC:83 -2018 (Part III) "Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, PIN, Metallic Guide and Plane Sliding Bearings (First Revision)"

IRC Notification No.27 dated 4th November, 2019 regarding suspension of above Code has been withdrawn and further Amendment No.2 of IRC:83 (part III) notified effective from 1st February, 2020.

Sl. No.	Page No/Para No./Clause No	For	Read
1.	3 /4 (Scope)	High performance elastomeric pressure pad in combination with specific internal seal and sliding material (e.g. UHMWPE) can be used subjected to availability of approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading international Specifications.	High performance elastomeric pressure pad in combination with specific internal seal and other sliding material can be used subject to availability of approval document from acceptable national / international approving authorities. .
2.	3/7 (Scope)	Sliding surfaces with a diameter of the circumscribing circle of single or multiple PTFE sheets or other approved sliding materials e.g. UHMWPE approved through ETA, FHWA or similar acceptance by other leading international Specifications, less than 75 mm or greater than 1500 mm, are outside the scope of this code. Sliding elements for use as temporary devices during construction, for example during launching of the superstructure, are also outside the scope of this code.	Sliding surfaces with a diameter of the circumscribing circle of single or multiple PTFE sheets or other sliding material (subject to availability of approval document from acceptable national / international approving authorities), less than 75 mm or greater than 1500 mm, are outside the scope of this code. Sliding elements for use as temporary devices during construction, for example during launching of the superstructure, are also outside the scope of this code.
3.	12/3.2.2	h = projection of PTFE/UHMWPE above the recessed portion	h = projection of sliding material above the recessed portion
4.	13/3.2.5	UHMWPE = Ultra High Molecular Weight Polyethylene	Delete line
5.	13/4.2	**Low Friction Thermo-Plastic Sliding Material (PTFE or UHMWPE)** The material shall be either polytetrafluoroethylene (PTFE) free sintered without regenerated material or Ultra High Molecular Weight Polyethylene (UHMWPE) having high material strength and low frictional properties. The pattern of dimples shall be as described in Fig. 4.1.	**Low Friction Thermo-Plastic Sliding Material (PTFE)** The material shall be either polytetrafluoroethylene (PTFE) free sintered without regenerated material or any other material having requisite material strength and low frictional properties. The pattern of dimples shall be as described in Fig. 4.1.
6.	14/4.2.2	Use of modified sliding material (UHMWPE) 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 can be considered for both horizontal and vertical sliding surfaces. Use of UHMWPE shall be subjected to availability of approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading International Specifications, reference of its usage in the bearing.	Use of other 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 can be considered for both horizontal and vertical sliding surfaces subject to availability of approval document from aaceptable national / international approving authorities. .

<table>
<tr><th>Sl. No.</th><th>Page No/Para No./Clause No</th><th>For</th><th>Read</th></tr>
<tr><td>7.</td><td>24/NOTE 2</td><td>NOTE 2: Elastomeric pad including internal seal having higher characteristic contact strength ($f_{e,k)}$) may be used subjected to the availability of approved documents from International Approval bodies like ETA, FHWA or similar acceptance by other leading International Specifications, reference of its usage in the bearing application, satisfactory and proven test and performance records etc.</td><td>Delete Para</td></tr>
<tr><td>8.</td><td>25/5.2.4.1</td><td>Table 5.2 Sliding Surfaces
<table>
<tr><th colspan="2">Flat Sliding Surface</th><th colspan="2">Guides</th></tr>
<tr><td>PTFE (Unfilled and dimpled) / UHMWPE (Dimpled)</td><td>Stainless Steel (SS)</td><td>PTFE (Unfilled) / UHMWPE Composite Material (CM1)</td><td>Stainless Steel (SS)</td></tr>
</table></td><td>Table 5.2 Sliding Surfaces
<table>
<tr><th colspan="2">Flat Sliding Surface</th><th colspan="2">Guides</th></tr>
<tr><td>PTFE (Unfilled and dimpled) / other sliding material subject to availability of approval document from acceptable national / international approving authorities (Dimpled)</td><td>Stainless Steel (SS)</td><td>PTFE (Unfilled)/ other sliding material subject to availability of approval document from acceptable national / international approving authorities

Composite Material (CM1)</td><td>Stainless Steel (SS)</td></tr>
</table></td></tr>
<tr><td>9.</td><td>28/5.2.4.8</td><td>When UHMWPE is used as sliding material, relevant ETA / FHWA documents shall be referred to determine the parameters described in Clause 5.2.4.1 to 5.2.4.7.</td><td>When material other than PTFE is used as sliding material, relevant approval document from acceptable national / international approving authorities shall be referred to determine the parameters described in Clause 5.2.4.1 to 5.2.4.7.</td></tr>
<tr><td>10.</td><td>35/5.3.2.1</td><td>PTFE is commonly used as plane sliding element at the interface capable to cater for translational movements. UHMWPE (if supported by independent certification like ETA / FHWA / similar certifying authority) can also be provided as may be required. Sliding assemblies should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding. To accommodate rotation about an axis in the plane of sliding additional arrangement shall be provided e.g. sliding assemblies may be combined with other types of bearings like elastomeric bearings, metallic rocker bearings, Pot bearings etc.</td><td>PTFE is commonly used as plane sliding element at the interface capable to cater for translational movements. Other sliding element, (subject to availability of approval documents from acceptable national / international approving authorities can also be provided as may be required. Sliding assemblies should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding. To accommodate rotation about an axis in the plane of sliding additional arrangement shall be provided e.g. sliding assemblies may be combined with other types of bearings like elastomeric bearings, metallic rocker bearings, Pot bearings etc.</td></tr>
<tr><td>11.</td><td>35/5.3.2.3</td><td>Sliding assemblies shall preferably have the stainless steel sliding sheet positioned above the PTFE or UHMWPE, so that the sliding surfaces are kept clean.</td><td>Sliding assemblies shall have the stainless steel sliding sheet positioned above the PTFE or other material supported with approval document from acceptable national / international approving authorities so that the sliding surfaces are kept clean.</td></tr>
<tr><td>12.</td><td>35/5.3.2.4</td><td>Surfaces mating with PTFE or UHMWPE shall always be made of Stainless Steel. The mating Stainless Steel surface shall always overlap the PTFE or UHMWPE even when the extreme movement occurs.</td><td>Surfaces mating with sliding material shall always be made of Stainless Steel. The mating Stainless Steel surface shall always overlap the sliding material even when the extreme movement occurs.</td></tr>
</table>

Sl. No.	Page No/Para No./Clause No	For	Read
13.	35/5.3.2.5	Load distribution through the bearing components and the adjacent structures shall be calculated considering the effective contact area after one vertical to one horizontal (1V:1H) of dispersion from confined PTFE / UHMWPE sheets. Effect of eccentricities shall be applied as per **Annexure B.**	Load distribution through the bearing components and the adjacent structures shall be calculated considering the effective contact area after one vertical to one horizontal (1V:1H) of dispersion from confined sliding material sheets. Effect of eccentricities shall be applied as per **Annexure B**.
14.	38/5.3.5.1	Sliding surfaces for guides of pot bearings with sliding assemblies shall be made of stainless steel sliding on either confined PTFE or UHMWPE or Composite Material (CM1). The coefficient of friction at the sliding interface of guides shall be considered as per Table 5.5.	Sliding surfaces for guides of pot bearings with sliding assemblies shall be made of stainless steel sliding on either confined PTFE or other sliding material subject to availability of approval document from acceptable national / international approving authorities or Composite Material (CM1). The coefficient of friction at the sliding interface of guides shall be considered as per Table 5.5.
15.	41 / 3.3.6.3.1	In case of dynamically loaded structures where extreme load fluctuations can occur, e,g. railway bridges, structures in high seismic zones (Zone IV and V), contribution due to friction shall not be taken into consideration while designing the anchorage i.e. $\mu_k = 0$	While designing the Bearing anchorages for seismic forces, contribution due to friction shall not be taken into consideration i.e. $\mu_k = 0$
16.	41/5.3.6.4.2	$F_{Rdu} = D \times L \times f_{cd}/\sqrt{3}$ F_{Rdu} = resistance offered by concrete in ULS f_{cd} = Permissible direct compressive strength of concrete, calculated as: $f_{cd} = \frac{0.67 \times f_{ck}}{1.5}$	$F_{Rdu} = 1.33\ D \times L \times f_{cd}/\sqrt{3}$ F_{Rdu} = resistance offered by concrete in ULS f_{cd} = Design Value of compressive strength of concrete, calculated as: $f_{cd} = \frac{0.67 \times f_{ck}}{1.5}$
17.	44/6.2.3	PTFE/ UHMWPE shall be secured and confined in the recesses preferably by shrinking fit method only for confinement. Glue may be used for vertical surfaces e.g. Guide/Guide bearing. For large PTFE/ UHMWPE sheets subdivided into parts, each individual part shall be confined into separate recess.	Sliding material shall be secured and confined in the recesses preferably by shrink fit method only. Glue may be used for vertical surfaces e.g. Guide/ Guide bearing. For large sliding material sheets subdivided into parts, each individual part shall be confined into separate recess.
18.	60	M_{Rd} = Reduced bending resistance $= \frac{k_u^2 \times L_{eff} \times f'_y}{\gamma_m}$	M_{Rd} = Reduced bending resistance $= \frac{(k_u^2 \times L_{eff} \times f'_y)}{(4 \times \gamma_m)}$
19.	66/Annexure G UHMWPE	UHMWPE– Valid approval document from international approving bodies like ETA, FHWA or similar acceptance by other leading international Specifications in the name of Bearing Manufacturer-	For material other than PTFE, approval document from acceptable national /international approving authorities in the name of Bearing Manufacturer