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IRC:83-2015 (Part-I)

STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES SECTION IX BEARINGS

Part-I : Roller & Rocker Bearings

(Second Revision)

INDIAN ROADS CONGRESS
2015

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3.	Secretary General, Indian Roads Congress	

STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES SECTION IX BEARINGS

PART-I : ROLLER & ROCKER BEARINGS

INTRODUCTION

The Bearings, Joints and Appurtenances Committee (B-6) of the Indian Roads Congress was constituted in 2012 with the following personnel:

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Gaharwar, Dr. S.S.	Member Secretary

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Honorary Treasurer, Indian Roads Congress	(Das, S.N.), Director General, (Road Development), Ministry of Road Transport and Highways
Secretary General, Indian Roads Congress	

The "Standard Specifications and Code of Practice for Road Bridges: Section IX: Part-1: Metallic Bearings", was first published in 1982. Its first revision was brought out in 1999 based on Working Stress Design Method. The Second Revision of this publication based on Limit State Design Method was undertaken by the Bearings Joints and Appurtenances Committee (B-6). The B-6 Committee constituted a Sub-Committee to prepare the revised draft document.

Dr. M.V.B. Rao	Convenor
Dr. B.P. Bagish	Member
Dr. S.S. Gaharwar	Member

The Sub-Committee prepared the revised draft document which was discussed in the meeting of B-6 Committee and the revised draft document was finalized for placing it before the Bridges Specifications & Standards Committee. The BSS Committee approved the revised finalized draft of "Standard Specifications and Code of Practice for Road Bridges: Section IX: Part 1: Roller & Rocker Bearings", in its meeting held on 8th August 2014. The Executive Committee in its meeting held on 18th August 2014, approved the draft document for placing it before the IRC Council. The IRC Council in its 203rd meeting held at New Delhi on 19th and 20th August 2014, approved the document for publishing.

1 SCOPE

This part of the Code deals with the requirements for the design, manufacture, testing and maintenance of steel rocker and roller bearings for road bridges. The provisions of this Code are meant to serve as a guide to both the design and construction engineers. This Code covers single and multiple roller bearings and rocker bearings generally used in Highway bridges.

This part is not applicable to Segmental/Cut rollers or Sliding type bearings. Further, roller or rocker bearings made with material other than those specified in **Clause 5** are outside the purview.

Bearings which are subjected to rotation greater than 0.050 radian under rare combination of action under SLS are outside the scope of this part of the Code.

1.1 Usage

Although robust and durable, the usage of Steel bearings in road bridges is less common in India due to increased adoption of POT bearings or Disk bearings. However, they continue to be used in Steel bridges and in Rehabilitation works of old bridges.

The revised IRC:83-Part-1 is based on Limit State Design Philosophy. The design of the various components shall be based on serviceability and/or ultimate limit state, depending on the safety classification of the limit state in consideration.

2 DEFINITIONS

For the purposes this Code, the following terms and definitions apply.

2.1 Anchor bolt

An Anchor bolt is an ordinary bolt anchoring the top and bottom plates to the structure.

2.2 Bottom Plate

A Bottom plate is a metallic plate which rests on the supporting structure and transmits forces from a bearing to the substructure.

2.3 Effective Displacement

The effective displacement is total relative movement between the structure in contact with the bearing.

2.4 Guide Bar

A guide bar is a device provided to maintain the alignment of the roller during movement, particularly during earthquakes.

2.5 Knuckle

It is a recess in the surface of the bottom/saddle plate or top plate housing a pin in preventing relative movement between two plates without restricting rotational movement.

2.6 Knuckle Pin

A cylindrical pin provided between recesses of the top and bottom parts of a bearing for arresting relative sliding movement of the top and bottom parts without restricting rotational movement.

2.7 Pendulum Guide

A device designed to reduce lateral loads and shaking movements transmitted to the structure.

2.8 Rocker

A component with a curved convex surface formed on one face. The curved surface can be a portion of a cylinder or sphere.

2.9 Rocker Bearing

A type of bearing in which sliding movement is not allowed but rotational movement is permitted (**Fig. 1**).

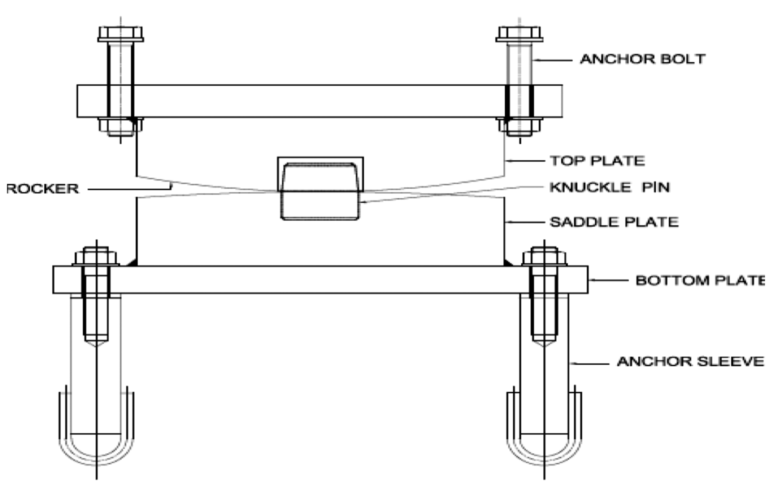

Fig. 1 Rocker Bearing at Fixed End

2.10 Rocker Pin

A lug on the surface of the bottom plate or saddle plate which fits into corresponding clear recess made in the top plate to prevent relative movement of the two plates without restricting rotational movement.

2.11 Rocker Plate

A metallic element which functions in contact with the rocker. It can have a flat or concave spherical surface.

2.12 Line Rocker Bearing

A bearing which is formed by a partial cylindrical surface rolling on a flat plate. It permits rotation about an axis parallel to the axis of the curved surface. If necessary, rocker and rocker plate can be inverted. A linear rocker could be of fixed or guided sliding or free sliding type (**Fig. 2**).

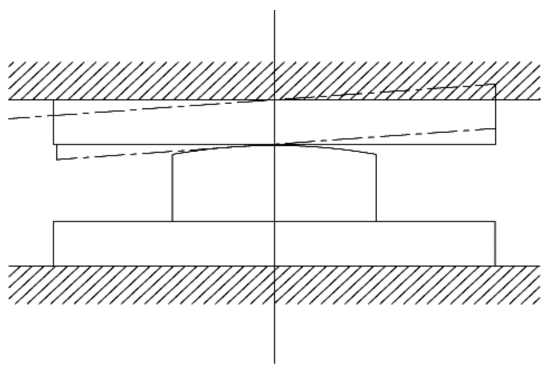

Fig. 2 Linear Rocker Bearing

2.13 Point Rocker Bearing

A bearing made of a convex spherical surface rolling on a flat or a concave spherical surface of a larger radius (**Fig. 3**).

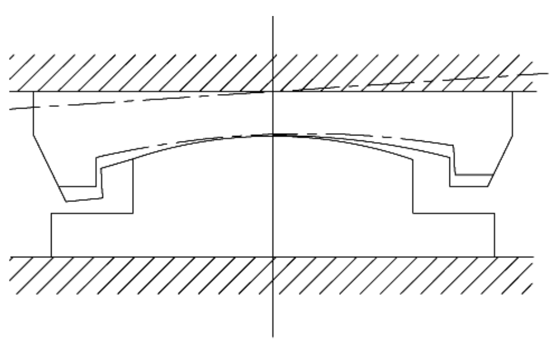

Fig. 3 Point Rocker Bearing

2.14 Roller

A machined concentric cylindrical component of a roller bearing. It rolls between top and bottom plates or between top and saddle plates.

2.15 Roller-Cum-Rocker Bearing

A type of bearing which permits both longitudinal movement by rolling and simultaneously allows rotational movement through a rocking mechanism (**Fig. 4**).

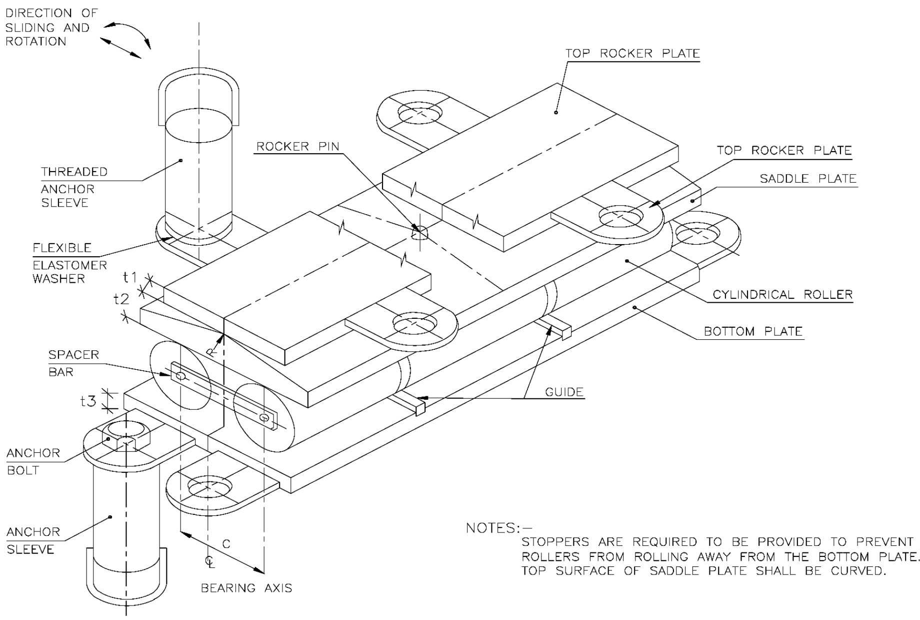

Fig. 4 Roller-Cum-Rocker Bearing

2.16 Roller Plate

An accurately machined flat component above or below a roller which transmits force to and from it and provides a flat surface for the roller to move.

2.17 Roller Bearing

A bearing formed by an upper and lower plates separated generally by one or two rollers which permit longitudinal movement by rolling. A pendulum guide is used for single roller (**Fig. 5**).

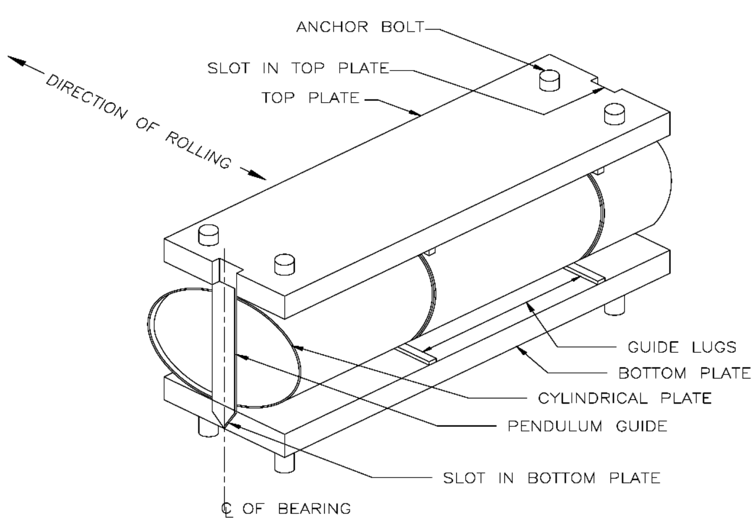

Fig. 5 Roller Bearing with Slots to Guide Movement of Roller

2.18 Multiple Roller Bearing

A bearing comprising more than two rollers in which the rollers are connected to each other with a link bar to ensure that they always move in tandem and maintain the clear gap between rollers, guided gear system is also adopted for the same purpose. A Knuckle pin takes care of the rotation of the super structure (**Fig. 6**).

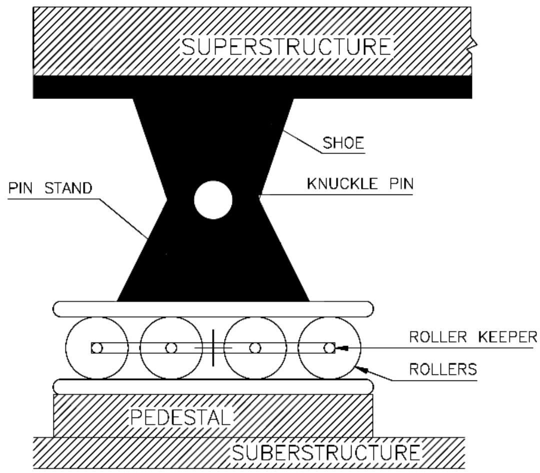

Fig. 6 Knuckle Pinned Multi Roller Bearing

2.19 Rotation Element

An additional element required with multiple bearings in order to share the applied normal forces between the rollers.

2.20 Saddle Plate

A plate which is positioned between the top plate and the roller(s).

2.21 Shear Dowel

A component which provides positive mechanical restraint to horizontal loads.

2.22 Spacer Bar/Link Plate

A bar loosely fixed at each end of a roller assembly for connecting the individual rollers in a nest and to facilitate movement of rollers in unison.

2.23 Stopper

A device/arrangement provided in the bottom plate, to arrest movement beyond the specified limit.

2.24 Supporting Plate

A plate placed intermediate between the roller or rocker elements and the structure for a better distribution of loads.

2.25 Top Plates

A metallic plate which is attached to the underside of the structure and which transmits all the forces transmitted from it to other members of the bearing.

3 SYMBOLS

The following symbols shall apply

α_d	total design angular rotation about the line of contact/one direction, in radian (rad)
b	width of Hertzian contact area, in millimeter (mm)
c	Centre to centre distance between rollers, in millimeter (mm)
E_d	design modulus of elasticity of ferrous material, in Newtons per square millimeter (N/mm^2)
e_d	total design eccentricity of vertical load, in millimeter (mm)
$e_{1,d}$	total eccentricity due to rolling friction (of rollers), in millimeter (mm)
$e_{2,d}$	design eccentricity due to rotation, in millimeter (mm)
$e_{3,d}$	design eccentricity due to translation, in millimeter (mm)
D	diameter of the roller at the contact surface, in millimeter (mm)
f_u	ultimate strength of material, in Newton per square millimeter (N/mm^2)
f_y	yield strength of material, in Newton per square millimeter (N/mm^2)
H	distance between horizontal section to be verified and roller/rocker contact area, in millimeter (mm)
L	effective length of roller/rocker surface, in millimeter (mm)
M_{Sd}	design rotation moment per unit length, in Newton millimeter (N-mm/mm)
μ_d	design coefficient of rolling friction (for rollers)
N_{RD}	design resistance of the roller plates/contact surface, in Newton (N)
N'_{RD}	design resistance per unit length, in Newton per millimeter (N/mm)
N_{RK}	characteristic resistance of the roller plates/contact surface, in Newton (N)
N'_{RK}	characteristic resistance per unit length, in Newton per millimeter (N/mm)
N_{sd}	design axial force, in Newton (N)
N'_{sd}	design axial force per unit length, in Newton per millimeter (N/mm)
γ_m	partial material safety factor
R	radius of convex contact surface, in millimeter (mm)
R_1	radius of concave contact surface, in millimeter (mm)
t_p	thickness of roller plate, in millimeter (mm)

t_1 & t_2 thickness of top and middle rocker plates (**Fig. 4**)

t_3 thickness of bottom roller plate (**Fig. 4**)

V_{sd} total transverse or shear force in Newton (N)

W_1 W_2 & W_3 widths of plates corresponding to t_1 t_2 and t_3

3.1 Abbreviations

ULS Ultimate Limit State

SLS Serviceability Limit State

UTS Ultimate Tensile strength

YS Yield Strength

4 FUNCTIONAL REQUIREMENTS

4.1 General

A roller bearing shall be capable of transferring normal forces between the superstructure and the substructure. It shall permit translation perpendicular to the roller axis and rotation about that axis. All the roller bearings shall incorporate a mechanical restraint system to resist applied horizontal forces along the axis of the roller.

A rocker bearing shall be capable of transferring applied vertical and longitudinal (horizontal) forces between the superstructure and the substructure. Line rockers shall permit rotation in one direction about the rocker axis. Point rockers shall permit rotation about any axis.

Rocker bearings may be used to resist horizontal forces. Resistance shall be by means of positive mechanical restraint such as shear dowels.

Bearings and supports shall be designed so that bearings or parts of bearings can be inspected, maintained and replaced if necessary, in order to enable them to fulfill their function throughout the intended life of the structure.

4.2 Load Bearing Capacity

The load bearing capacity of the rocker or roller bearing shall be obtained from the design verification as a function of the geometry and the steel properties.

5 SPECIAL REQUIREMENTS

5.1 Roller Bearings

Only full cylindrical rollers are permitted. A base plate of adequate width shall be provided to cater for anticipated movements of the supporting structure.

5.2 Seismic Zones

For Seismic Zones IV and V, the roller and rocker bearing components shall have suitable guides to prevent them from being displaced during earthquakes. The components shall allow for movement as calculated.

5.3 Skew or Extra Wide or Curved Bridges

For bridges with skew angle < 20° the bearings shall be placed at right angles to the longitudinal axis of the bridge.

Steel bearings are not preferred for bridges with skew angle > 20º and for very wide (> 2 x Span Length) or curved bridges. In such cases other types of bearings are chosen.

5.4 Rotation Capability

The rotation capability of the roller or rocker bearing is an intrinsic characteristic of the system based on its geometry and shall be declared by the manufacturer. Its maximum value shall be 0.050 radian.

6 MATERIALS AND SPECIFICATIONS

6.1 General

Only ferrous materials as specified in the following paragraphs shall be used in the manufacture of rollers, rocking devices and roller/rocker plates. Such devices shall be examined of cracks by ultrasonic methods in accordance with the requirements specified in level 3 of IS:9565 or by magnetic particle or dye penetration methods. Flaws in welds shall be detected as per IS:5334. No component with linear defects revealed by the procedures indicated are acceptable.

The hardness of rollers, rockers and roller plates shall be tested in accordance with IS:1500 to determine the Brinell Hardness Number (BH) .

The hardness of rollers, rockers and roller plates is also determined on Vicker's (Pyramid indentation) scale HV to be tested as per IS:1754 and ASTM E 384.

6.2 Mild Steel

Mild steel used for components of bearing shall conform to the requirements of IS:2062 E 250 (Gr-B). The minimum yield strength shall be 240 N/mm^2 for any component. For sub-zero condition Grade A ,C & D of IS:2062 shall be used.

Rollers are made of cast steel or forged steel, but not from mild steel. However, the cylindrical rollers can alternatively be turned from railway carriage and wagon axles (R 19) as per **Clause 2003.1.2** of MoRTH Specifications.

6.3 Cast Steel

Cast steel shall be in accordance with 280-520 W or 340-570 W of IS:1030. The castings shall be ultrasonically examined as per IS :7666 with acceptance standard as per IS:9565.

6.4 Forged Steel

Forged steel can be used for the components of bearings. The raw material shall comply with Class 3, 3A or 4 of IS:1875 and the forged product shall comply with Class 3, 3A or 4 of IS:2004 and normalized.

6.5 High Tensile Steel

High Tensile steel to be used for components of bearings shall comply with E 350 (Fe 490) of IS:2062.

6.6 Welds

Welds shall conform to IS:816, IS:1024 and IS:9595 as appropriate, using electrodes as per IS:814 and IS:1395.

For all components exceeding 20 mm in thickness requiring welding, the Carbon equivalent (CE) shall be ascertained and requirement of pre-heating up to 200ºC shall be done as per **Clause 2003.1.2** of MoRTH Specification.

The maximum Carbon Equivalent (CE) in E 250 (Fe 410 W) shall be 0.39 based on ladle analysis.

$$CE = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Ni + Cu)}{15}$$

6.7 Fasteners

Bolts, screws, nuts and lock nuts shall generally conform to IS:1363 (Parts 1 to 3), IS:1364: (Parts 1 to 3). High strength structural bolts, nuts and hardened and tempered washers shall conform to IS:3757, IS:6623 and IS:6649 respectively.

6.8 Grease

The grease for bearings shall conform to the requirements of IS:503 (Grade 4). Silicon grease shall conform to IS:14383.

6.9 Curved Surfaces

The curved surfaces of rollers/line rockers shall be of cylindrical shape. Those of point rockers shall be spherical.

6.10 Surfaces in Contact

Surfaces in contact shall have the same nominal strength and hardness.

6.11 Preventing Sliding

Mechanical devices shall be provided to prevent contact surfaces of rocker bearings sliding on one another. When gearing is used in roller bearings, the pitch circle diameter of the gear teeth shall be the same as the diameter of the rollers.

7 MATERIAL PROPERTIES AND DESIGN VALUES

7.1 Mild Steel components

The properties of mild steel components given in **Table 1** shall be determined as per IS:2062.

Table 1 Properties of Mild Steel

1.	Ultimate Tensile Strength (MPa)	410 MPa
2.	Yield Strength	240 MPa
3.	Percentage elongation	23%

$$\gamma_m = 1.25 \text{ on UTS}$$

$$\gamma_m = 1.15 \text{ on YS}$$

N.B : Lower of the two values to be considered for the purpose of design.

7.2 Equivalent Stresses Under Combined Shear and Bending

Equivalent stresses under combined shear and bending for mild and high tensile steel plates used in bearings is given in **Table 2**.

Table 2 Equivalent Stresses

Quality of Steel	Value of Yield Strength (f_y)		Ultimate Strength (f_u)
	Maximum	**Minimum**	
	MPa	MPa	MPa
Mild Steel conforming to IS:2062 Gr. E 250 (Fe 410)	250	230	410
High tensile Steel conforming to IS:2062 Gr. E 350 (Fe 490)	350	320	490

$$\gamma_m = 1.25 \text{ on UTS}$$

$$\gamma_m = 1.15 \text{ on YS}$$

N.B. : Lower of the two values to be considered for the purpose of design.

7.3 Design Value of Strength for Welds

Welded connections shall conform to **Clause 512.4** of IRC:24

The design value of strength in fillet weld is based on its throat area. On plug welds, the entire area of slot shall be filled to mobilize shear stress. Stresses in butt welds shall not exceed those permitted in the parent metal. Butt welds shall be treated as parent metal with a thickness equal to the throat thickness.

$$\gamma_m = 1.25 \text{ for shop welds}$$

$$\gamma_m = 1.50 \text{ for site welds}$$

7.4 Design Value of Strength for Cast Steel in Bearings

The design value of strength and percent elongation for cast steel conforming to IS:1030 are given below:

Quality	Tensile strength	Elongation
W 280-520	520 MPa	18 %
W 340-570	570 MPa	15%

γ_m = 1.25 on UTS

γ_m = 1.15 on YS

N.B.: Lower of the two values to be considered for the purpose of design.

7.5 Design Value of Strength Under Bearings or Bed Plates

The area of bearings or bed plates shall be so proportioned that no uplift occurs when the eccentricity in application of loads mentioned in **Clause 8.1 and 8.2** is considered.

7.6 Stone Masonry

Stone masonry sub-structures continue to be used in some parts of the country which are provided with RCC caps for uniform distribution of loads from bearings.

The maximum bearing pressure as per IS:1597 Part 1 on stone masonry shall not exceed the following limits: -

For

Granite	100 Mpa
Basalt	40 MPa
Sand Stone	30 MPa
Quartzite	150 MPa

γ_m = 8 for Basalt and Sand stone

γ_m = 3 for Granite and Quartzite

ULS check is necessary for pier/abutment caps in RCC.

7.7 Plain and Reinforced Concrete

The strength and deformation characteristics of concrete at 28 days may be taken as per **Table 6.5** of IRC:112. For compressive strength other than 28 days, **Clause 6.4.2.2** of IRC:112 may be referred to. The following material safety factors may be chosen :

γ_m = 1.5 for basic as well as seismic combinations for ULS

γ_m = 1.2 for accidental load combination

γ_m = 2.1 for SLS

γ_m = 3.0 for grout in anchorages (suggested value)

The centre of pressure under flat bearing plates attached to the girders shall be assumed to be at one-third of the length from the front edge.

8 DESIGN CONSIDERATIONS

8.1 The design of rocker and roller bearings is based on the assumption that load passes through a Hertzian contact area between two surfaces of dissimilar radii. High stresses are induced when a load is applied to two elastic solids in contact. Hertz developed a theory to calculate the contact area and pressure between the two surfaces and predict the resulting compression and stress induced in the objects. Design verification with respect to vertical loading and, longitudinal forces and resulting rotation with or without movement under most critical combination of actions shall be done. The bearings shall be designed to withstand the maximum vertical reactions and longitudinal force under the most critical combination of Actions. Provision shall also be made against any uplift to which the bearings may be subjected under the action of the above forces.

8.2 Loads and Forces

All the actions and their combination in accordance with **Tables 3.1 to 3.3** of IRC:6 are considered for design of bearings.

The provisions in Para 8.4 of the Code for additional rotations and movements, including those of slender/tall supporting structure shall be considered for reliability.

The provisions in Para 8.5 are considered for minimum movements for strength analysis at ULS.

Performance and durability of bearings designed according to this part of the code are based on the assumption that requirements established as relevant, are complied with.

The design values of the effects (forces, deformations, movements) from the actions on all the supports of the structure shall be calculated from the relevant combination of actions according to IRC:6-2014.

8.3 Movements

Roller bearings accommodate translation in longitudinal direction only. Single rollers permit rotation about line of contact but multiple rollers require additional elements to accommodate rotation.

In addition to design movements and rotations, increased movements for reliability and minimum movements for strength analysis are considered as follows:

8.4 Increased Movements for Reliability

a) **Rotation**

± 0.005 radians or ± 10/r whichever is the greater (r is radius measured in mm);

b) **Translation**

± 20 mm in both directions of movement with a minimum total movement of ± 50 mm in the direction of maximum movement and ± 20 mm transversely unless the bearing is mechanically restrained.

These requirements only apply for the design of movements capacities. They shall not be used where stresses are being calculated.

Note 1 : Where movements are small their calculation tends to be approximate. This applies to most rotational movements and to small translational movements. The purpose of this clause is to ensure that in such cases there is an adequate margin in the bearing design to ensure that a small error in calculation or setting does not lead to a serious malfunction of the bearing.

c) **Temperature**

While specifying the magnitude of the translation and rotation for bearing design, the bridge designer shall account for the contingency factor viz. construction tolerances, variation with respect to the mean temperature at the time of installation.

d) **Creep and Shrinkage**

Appropriate assessment as per **Clauses 6.4.2.6 and 6.4.2.7** of IRC:112 are to be considered.

8.5 Minimum Movements to be Considered for the Strength Analysis at ULS

For the strength analysis of the bearing at ULS the resultant rotational movement shall be taken as not less than ± 0.003 radians and the resultant translational movement not less than ± 20 mm transversely unless the bearing is mechanically restrained.

Note 2 : Particular care should be taken when calculating bearing movements if the result is obtained from two large movements of opposite direction (difference between large numbers). The most adverse combination of factors should be assumed to give the maximum possible movement. Special care should also be taken to account for the reversing movements such as those due to thermal expansion/contraction and seismic effects.

9 DIMENSIONING OF COMPONENTS

9.1 Dimension of Roller

The ability of curved (rocker and roller) surfaces and plates to withstand deformation under load is dependent upon the hardness of the material of which they are made. Although, there is no constant relationship between hardness and yield stress of steel, but one exists between hardness and ultimate strength. Consequently the following expressions are based on the ultimate strength of the material.

The design axial force per unit length of roller contact N'_{Sd} shall meet the following condition under the fundamental combination of actions:

$$N'_{Sd} \leq N'_{Rd}$$

where,

$N'_{Rd} = N'_{Rk}/\gamma^2_{m}$ is the design value of resistance per unit length of roller contact.

N'_{Rk} is the characteristic value of resistance of the contact surface per unit length

$$N'_{Rk} = 23 \times R \times f_u^2/E_d$$

The recommended value is $\gamma_m = 1$

In determining the values of N_{Sd} the effects of asymmetric loading due to transverse eccentricities and applied moments shall be considered. (**Fig. 7**).

9.2 Dimensions of Roller Plates

Roller plates shall be dimensioned in the direction of displacement to allow for movement calculated for the fundamental combination of actions in accordance with IRC:6-2014 plus an additional roller design movement of 2 x t_p or the thickness of the roller plate, or 20 mm whichever is greater. The length of the plates parallel to the roller axis shall not be less than the length of the roller. In determining the thickness of the roller plates, the following shall be satisfied using the load distribution shown in **Fig. 7** under the combination of actions as per IRC:6 under ULS, 'Basic', 'Accidental', 'Seismic'. The gap between the rollers shall not be less than 50 mm in case of multiple rollers (of minimum dia 100 mm).

$$N_{Sd} \leq N_{Rd}$$

where,

$N_{Rd} = N_{Rk}/\gamma_m$ the design value of resistance.

$N_{Rk} = f_y\,(2t_p + b)L$

where,

$\gamma_m = 1.1$

9.3 Line Rocker

9.3.1 *Dimensions of Line Rocker*

The design axial force per unit length of rocker contact N'_{Sd} shall meet the following condition under the fundamental combination of actions:

$$N'_{Sd} \leq N'_{Rd}$$

where,

$N'_{Rd} = \dfrac{N'_{Rk}}{\gamma^2_m}$ is the design value of resistance per unit length of rocker contact.

N_{Rk} is the characteristic value of resistance of the contact surface per unit length

$$N'_{Rk} = 23 \times R \times \frac{f_u^2}{E_d}$$

The recommended value is $\gamma_m = 1$

In determining the values of N'_{RK} the effects of asymmetrical loading due to transverse eccentricities shall be considered.

9.3.2 *Point Rocker in Spherical Seating*

The concave and convex spherical radii shall be selected so that :

$$N_{Sd} \leq N_{Rd}$$

where,

$N_{Rd} = N_{Rk}/\gamma^3_m$ is the design value of resistance of the contact surface

N_{Rk} is the characteristic value of resistance of the contact surface

The recommended value is γ_m =1

$$N_{Rk} = 220 \times \left[\frac{R_1 - R}{R_1 \times R}\right]^2 \times f^3_u \times \frac{1}{E^2_d}$$

9.3.3 *Point Rocker on a Flat Surface*

The spherical radius R in contact with a flat surface shall be selected so that:

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

where,

$N_{Rd} = \frac{N_{RK}}{\gamma^3_m}$ is the design value of resistance

N_{RK} is the characteristic value of resistance of the contact surface

$N_{RK} = 220\ R^2 \times f_u^3 \times \frac{1}{E_d^2}$

The recommended value is $\gamma_m = 1$

9.4 Load Dispersion for Bearing Pedestals

The pedestals of bearings shall be so proportioned that a clear offset of 150 mm beyond the edges of bearing is available. The minimum height of pedestal shall be 150 mm. The allowable bearing pressure under a bearing with a near uniform load is given by the expression :

$C = C_o \times \sqrt{A1/A2} \leq 3\ C_o$

where,

C_o = Permissible direct compressive stress in concrete at the bearing area of the plate

A1 = Dispersed concentric area which is geometrically similar to A2 and also the largest area that can be contained in the plane A1 (Maximum width of dispersion beyond the loaded area face shall be limited to twice the height)

A2 = Loaded area. The projection of bases beyond the face of bearing supported on it shall be less than 150 mm in any direction.

9.5 Where the eccentricity of loads and longitudinal forces are considered along with direct compressive forces, the calculated direct bearing stress and the flexural stress, shall satisfy the following equation :

$$\frac{\sigma c_o, cal}{\sigma c_o} + \frac{\sigma c, cal}{\sigma c} \leq 1$$

where,

σc_o, cal = the calculated direct bearing stress

σc_o = the allowable direct bearing stress as per IRC:112

σc, cal = the calculated flexural stress

σc = the permissible flexural stress in concrete or σc_o whichever is higher

9.6 Rocker and Roller-cum-Rocker Bearings

9.6.1 *Load Distribution of Rockers to other Components*

The rockers and rocker plates shall be so proportioned that loads are adequately distributed to adjacent components. The maximum load dispersion through a component of bearing shall be taken as 45º unless a greater angle is justified by calculations, which take into account the characteristics of the adjacent components and materials. In no case shall load dispersion be assumed beyond a line drawn at 60º to the vertical axis (**Fig. 7**).

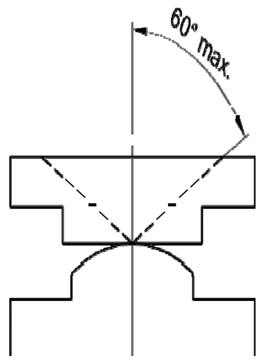

Fig. 7 Load Distribution to Components in Rocker Bearing

9.6.2 *Load Distribution of Rollers to Other Components*

For roller bearings the stiffness of the supporting plates is of paramount importance therefore the roller plates shall be so proportioned that loads are adequately distributed to adjacent components. The maximum load dispersion through a component shall be taken as 45º unless a greater angle is justified by calculations which take into account the characteristics of the adjacent components and materials. In no case shall load dispersion through bed plates be assumed beyond a line drawn at 60º to the vertical axis. (**Fig. 8**).

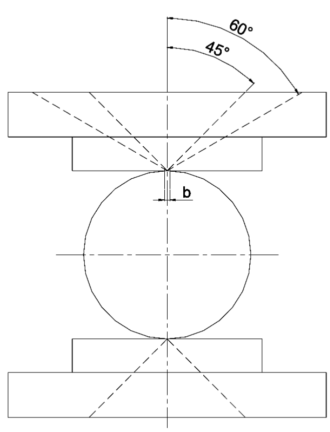

Fig. 8 Load Distribution to Components in Roller Bearing

9.7 Top, Saddle and Bottom Plates

The plates shall be symmetrical to the bearing axis. They shall be of cast steel/forged steel/ high tensile steel.

9.7.1 *The width of plates shall not be less than either of the following :*

i) 100 mm or

ii) The distance between the centre to centre distance of outermost rollers (where applicable) plus twice the effective displacement during service or twice the thickness of the plate plus 10 mm as margin for error in sitting. (The centre to centre distance of outer most rollers. if these are two or more. For single roller bearings it shall be taken as zero), **Fig .9**.

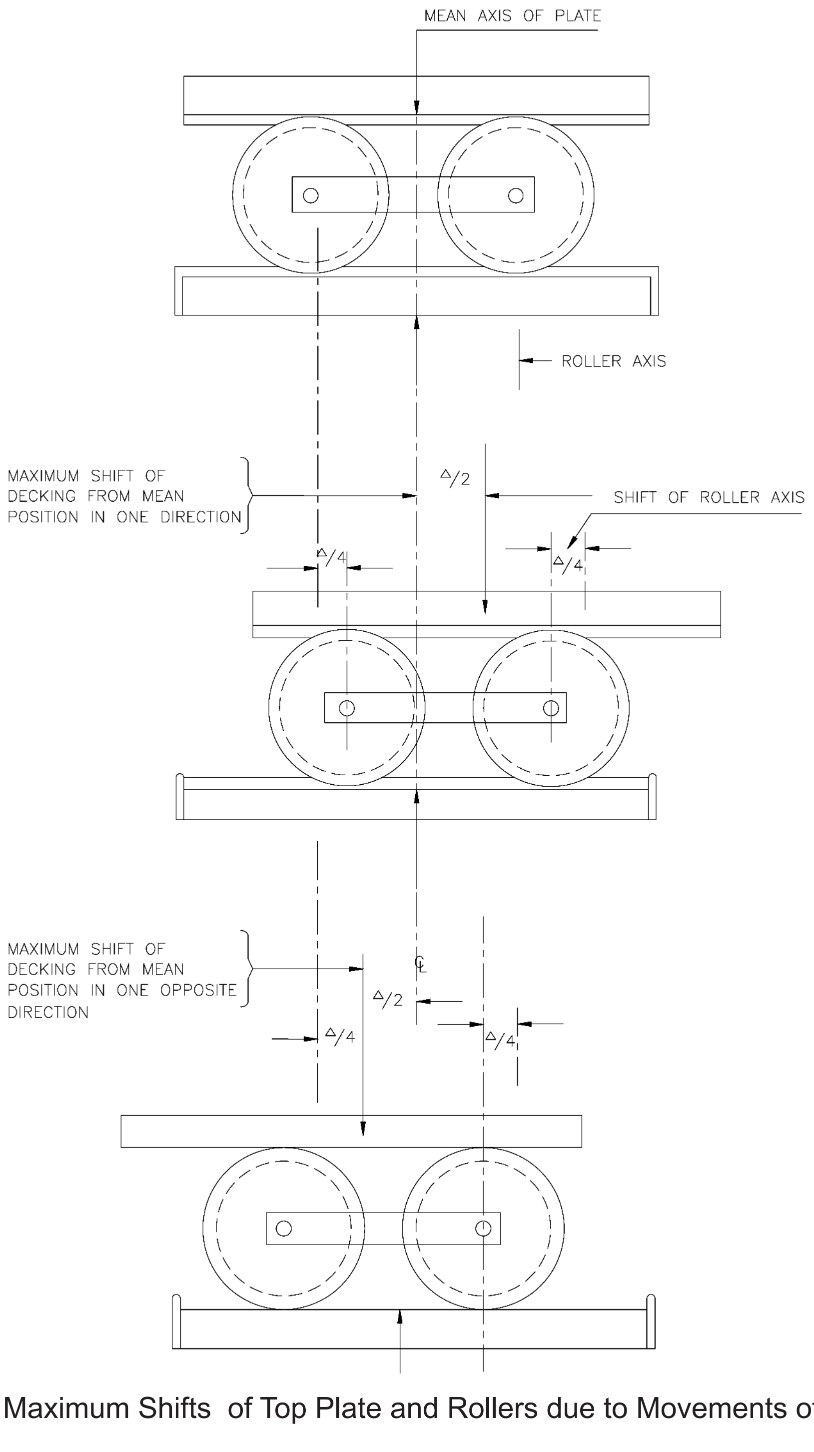

Fig. 9 Maximum Shifts of Top Plate and Rollers due to Movements of Deck

9.7.2 The thickness of the plate shall not be less than (i) 20 mm or (ii) 1/4th the distance between consecutive lines of contact, whichever is higher.

9.7.3 The thickness of the plate shall also be checked, based on the contact stresses arrived at accounting for the actual width of the plate provided, to satisfy the requirements of structural design and permissible stresses as laid down in **Clause 7.1 and 7.2**.

The minimum width of various plates shall be calculated from the following formulae:

$W_1 \geq$ 100 or $2t_1$ whichever is greater

$W_2 \geq$ 100 or $[(b-1)\ C + 2\Delta]$ or $[(n-1)\ C + 2t_2]$ whichever is greatest

$W_3 \geq$ 100 or $[(b-1)\ C + 2\Delta]$ or $[(n-1)\ C + 2t_3]$ whichever is greatest

Δ = Effective displacement

C = Centre to Centre distance of rollers

n = No. of roller t_1, t_2 and t_3 as in **Fig. 9**.

W_1 W_2 and W_3 Width of plates corresponding to t_1, t_2 and t_3

9.8 Miscellaneous Components

9.8.1 *Design of Knuckle*

The knuckle pins shall be so designed as to be safe in bearing and resist the horizontal shear due to the maximum longitudinal forces acting on the bearing. The permissible bearing stress shall be limited to 120 MPa. The working stress shall be calculated on the projected area of the mating surface.

9.8.2 *Rocker Pin*

9.8.2.1 The pins provided in bearings shall be designed to resist the maximum longitudinal force acting on the bearings. The pins shall be driven force fit in the saddle or bottom plate and shall have corresponding recesses in the top plate with adequate tolerance to allow for rocking.

9.8.2.2 The rocker pin and the corresponding recess shall satisfy the following:

i) The diameter of the rocker pin ‘d’ shall not be less than 16 mm.

ii) The pin shall be force fit to a depth of 0.5 d.

iii) The pin shall project 0.5 d and have a taper in the projected portion to accommodate the rotation of the structure.

iv) The diameter of the corresponding recess shall be 1.1 d or d + 2.5 mm, whichever is less.

v) The minimum clearance above the top surface of the rocker pin shall be 2.5 mm.

9.8.2.3 Spacer bars

To ensure movement of multiple rollers in unison, spacer bars shall be provided but the arrangement shall be such that the rollers can rotate freely, as in **Fig. 4 and Fig. 5**.

9.8.3 *Guide Lugs and Grooves*

9.8.3.1 To prevent transverse displacement of the bearing components suitable guide lugs in plates with corresponding groves in rollers shall be provided.

9.8.3.2 The guide lugs and the corresponding grooves shall satisfy the following :

i) The number of guides and lugs shall be 2 for each case and increased to 3 where the ratio of roller length to diameter exceeds 6.

ii) The width 'b' of the lug shall not be less than 10 mm.

iii) The guide lug shall be force fit to a depth of 0.5 b.

iv) The guide lug shall project 0.5 b.

v) The corresponding groove shall have a clearance of 1.00 mm on the sides and the top of the guide lug.

9.8.4 *Stoppers*

To prevent rollers from rolling off the bottom plate, suitable stoppers shall be provided.

9.8.5 *Anchor Bolts*

9.8.5.1 The top and bottom plates shall be suitably anchored to the girder and the pier abutment caps or pedestals by means of anchor bolts.

9.8.5.2 The anchor bolts shall be designed to resist the maximum horizontal force acting on the bearing.

9.8.5.3 The minimum length of the anchor bolts in concrete may be kept equal to its diameter subject to a minimum of 100 mm.

9.8.5.4 Anchoring of Deck to Substructure

The anchoring arrangement shall be designed for such a force so as to provide for a stability equivalent to 1.1 times the overturning moment due to permanent load (or 0.9 times if the effect is more severe) and 1.6 times the overturning moments due to temporary loads or live loads.

9.9 Eccentricities

9.9.1 *Line Rocker Rotational Eccentricity*

Eccentricity, e_2, due to rotational movement between the components is:

$e_2 = \alpha_d \times R$ as given in **Fig. 10**

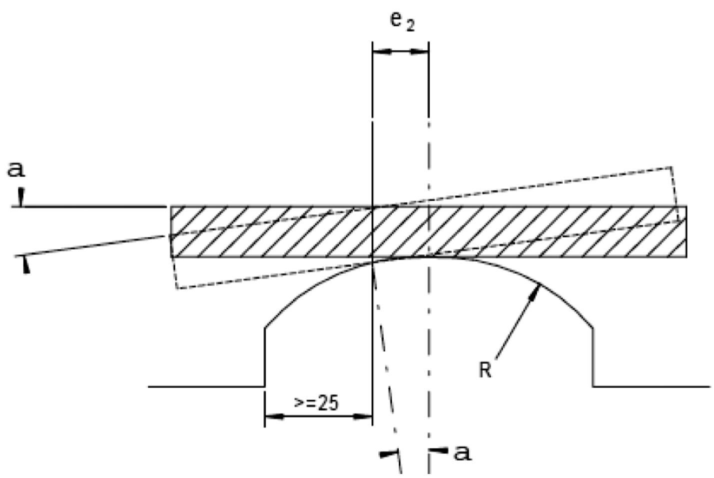

Fig. 10 Line Rocker Eccentricity

The total rocker eccentricity due to rotational eccentricity effect shall be taken as $e_{2d} = 2 \times e_2$ to allow for the effect of rolling friction at the contact surfaces.

9.9.2 *Single Roller Rotational Eccentricity*

9.9.2.1 Eccentricity due to rolling friction

This eccentricity results from the lateral force $V_{Sd} = \mu_d N_{Sd}$ which has to be taken into account when designing the connection devices of the bearing and fixed point of the bridge.

$$e_{3,d} = \mu_d [R+(R+H)]$$

9.9.2.2 Translational eccentricity

Eccentricity, $e_{3,d,}$ produced by relative movement (displacement) of top and bottom roller plates is:

$e_{3,d}$ = displacement/2 as given in **Fig. 11**.

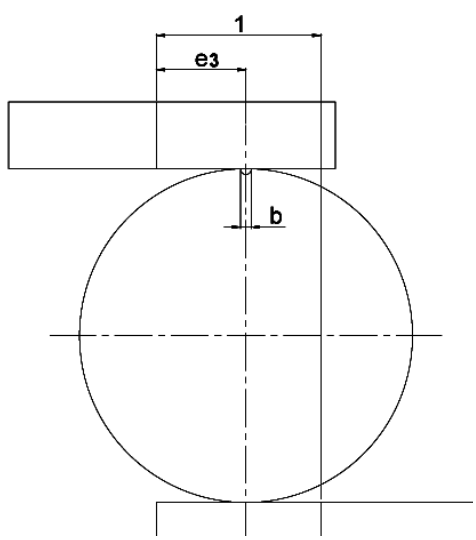

Fig. 11 Translation Eccentricity of Single Roller

9.9.2.3 Rotational eccentricity

Eccentricity caused by the rotational movement of the bridge $e_{2,d} = \alpha_d R$

Note: Other eccentricities can co-exist with those detailed in this clause and designers should be aware of the possibility of their existence. In general their effects are small compared with the above and can be ignored.

9.9.2.4 Eccentricity due to rotation movement of multiple rollers

Multiple roller bearings have no inherent rotation capacity. Design rotation moment, $M_{Sd,}$ is therefore determined by the characteristics of the additional rotation element designed in accordance with the appropriate part of this part of the code the design eccentricity resulting from the action of this rotational element shall be calculated in accordance with the relevant part of this part of the code.

Design eccentricity $e_{2,d}$ shall be considered when determining the individual roller design loads and in determining the total design eccentricity on the structure.

$$e_{2,d} = M_{Sd}/N_{Sd}$$

9.9.2.5 Transverse eccentricity

In the absence of any transverse rotation capability a transverse eccentricity of L/10 shall be assumed.

9.9.2.6 Total eccentricity

The total eccentricity to be considered shall be the Vectorial sum of the individual foregoing eccentricities.

9.10 Particular Requirements

9.10.1 *Length of Rollers*

The length of a roller shall not be less than twice its diameter nor greater than six times its diameter. The minimum diameter of roller is 100 mm

9.10.2 *Multiple Rollers*

Where a bearing has more than one roller an additional element in accordance with other parts of this code shall be included to accommodate rotation. The effects of any rotation movements from this element shall be included when calculating the roller forces by taking into account the corresponding eccentricities. The load per roller shall be calculated at the extreme of the expected movement. In addition where a bearing has more than two rollers the limiting values for design load effects shall be taken as two-third of the value.

9.10.3 *Corrosion in the contact line*

If the materials used for the roller and roller plates are not intrinsically corrosion resistant then other provisions shall be made in the design to prevent corrosion in the area. These measures may take the form of grease boxes, oil baths, flexible seals or other methods which can be shown to be effective or which have been found satisfactory during use. Where dissimilar materials are used in combination the effects of electrolytic corrosion shall be considered.

9.10.4 *Alignment of components*

Provision shall be made to ensure that bearing components remain correctly aligned with each other and clamped together between manufacture and installation. Temporary transit devices and devices intended to maintain alignment during installation shall not be used to locate the structure.

9.10.5 *Alignment of bearings*

It is particularly important that the axis of the rolling element is correctly aligned in the structure and accurate alignment marks defining the axes of the roller shall be indelibly scribed on outer surfaces of accessible plates.

9.10.6 *Design coefficient of friction*

The design friction coefficient μ_d shall be taken as 0.02 for steel with a hardness $\geq$ 300 HV and 0.05 for all other steels.

Note: The coefficient of friction for rolling contact surfaces of rollers used for structural design purposes can be determined by test. Test results should be increased by a factor of 2 to give a design coefficient of friction to allow, for the long-term effects of wear, corrosion protection and accumulation of debris.

9.10.7 *Anchor Bolt*

All the longitudinal forces from the super-structure are transmitted to the supporting structure through the fixed end of bearing. Any friction between the bed block and base plate or saddle plate and bottom chord/soffit is completely ignored and the entire horizontal force is assumed to be transmitted by the connecting bolts. The bolts are thus checked against shear failure and also for safe bearing stresses. The permissible shear or bearing stresses for different grades of steel.

9.10.8 *Combination with Other Elements*

When a roller bearing is combined with elements from other parts of this code the characteristics and kinetics of all elements and their interaction, together with their stiffness, movement and eccentricities of the adjacent structural components shall be considered.

10 WORKMANSHIP AND TOLERANCES

10.1 All surfaces of the major components like top plates, saddle plate, base plates, rollers of the bearings shall be machined all over for correct alignment, interchangeability, proper fitting, etc.

10.2 Plates

The plate dimensions shall be in accordance with the approved drawing. Tolerance on the length and width of the plate shall not exceed + 1.0 mm, tolerance on the thickness of the plate shall not exceed + 0.5 mm and no minus tolerance shall be allowed.

10.4 Rollers and Curved Surfaces

10.4.1 The tolerance on the diameters of both rollers and convex surfaces shall conform to K 7 of IS:919.

10.4.2 The tolerance on the diameter of concave surfaces shall conform to D8 of IS:919.

10.4.3 *Castings*

No minus tolerance will be allowed in the thickness of any part of the castings. The edge of all ribs shall be parallel throughout their length.

10.4.4 *Flatness*

Tolerances on flatness of rocker/roller plates in the direction of the rocker/roller axis shall be in accordance with **Table 3**.

Table 3 Flatness Tolerance for Rocker/Roller Plates

Material	**Length of Roller Contact L (mm)**	
	≤ 250	**> 250**
	Tolerance (mm)	**Tolerance (mm)**
Steel ≤ 300 HV	0.1	0.0004 x L
Steel > 300 HV	0.075	0.03

10.4.5 Surface Profile Tolerance

The surface profile tolerance for the length of the curved surface over which contact can occur shall be in accordance with **Table 4**.

Table 4 Surface Profile Tolerance for Rockers/Rollers

Material	**Length of Roller Contact L (mm)**	
	≤ 250	**> 250**
	Tolerance (mm)	**Tolerance (mm)**
Steel ≤ 300 HV	0.05	0.05
Steel > 300 HV	0.025	0.025

Note: In **Tables 3 and 4**, the gauge length is the length of the roller.

10.5 Surface Roughness

The surface roughness of the rocker/roller and rocker/roller plate, measured in accordance with IS:3073, shall not exceed the values shown in **Table 5**.

Table 5 Surface Roughness

Material	Surface Roughness (μm)
Steel $\leq$ 300 HV	25
Steel > 300 HV	6.3

Before installation, the deviation from parallelism between any two pairs of points on the surfaces shall be not more than 0.1 percent when the difference in the vertical distance between each pair is expressed as a percentage of the horizontal distance separating them.

10.6 Tolerances in Multiple Rollers

The tolerance on size of multiple rollers with respect to their nominal diameter shall be + 0.08 mm/-0.0 mm.

11 ACCEPTANCE CRITERIA AND TESTING

11.1 Acceptance Criteria

Unless agreed upon otherwise between the Engineer and the Manufacturer, the Manufacturer shall furnish a complete Quality Assurance Program comprising the process of quality control, raw material testing, various stages of manufacture, testing on bearing components as well as testing on complete bearing etc. in conformity with relevant Codal stipulations prior to the commencement of manufacture. The said Quality Assurance Program shall be approved by the Engineer/Accepting Authority. Manufacturing process, quality assurance, testing, documentation, etc. shall be carried out in conformity with the approved quality assurance program. Proper documentation, records and certificates shall be maintained at all stages of manufacture and inspection by manufacturer to ensure to the conformity with the approved Quality Assurance Program.

The Engineer may appoint an authorized inspection agency on his behalf for the purpose of inspection as per approved Quality Assurance Program to certify the acceptance or otherwise of the bearings.

11.1.1 Test certificates of reputed testing laboratories for all raw materials shall be submitted. If such test certificates are not available then bearing manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and shall furnish the test results. Engineer or his representative may carry out independently tests on raw materials and witness the manufacturing process.

11.1.2 All casting and forgings shall be annealed/normalized and the heat cycle record shall be submitted to the Inspecting Officer/Engineer for scrutiny. Inspecting Officer/Engineer may ensure the proper reduction ratio. Suitable weld data record shall be maintained and submitted.

11.1.3 The Engineer shall reserve the right to witness such inspection at manufacturer's workshop. For this, bearing manufacturer shall have in-plant minimum testing facilities as follows :

i) Fully equipped chemical test laboratory to find out Carbon, Sulphur, Phosphorous, Manganese, Silica and other elements as required.

ii) UTM of minimum 40 t capacity

iii) BHN testing equipment of 3000 Kgf (Hydraulic type)

iv) Ultra sonic flaw detector

v) Metalography for checking of microstructure of different materials

vi) Load testing machine of required capacity with accessories for imparting rotation and lateral loading.

11.1.4 Bearing manufacturer shall maintain a list of consumption of raw materials including test records, for a period of at least preceding two years.

Test certificates of bearings manufactured during preceding two years shall be made available to the Inspecting Officer(s)/Engineer at manufacturer's works.

11.1.5 Bearing manufacturer shall employ full time graduate Engineers staff, qualified to manufacture bearings under quality control and shall have full time trained Scientist in chemical and physical testing besides qualified person for ultrasonic testing.

Bearing manufacturer shall have qualified/certified welders.

11.2 Testing

11.2.1 The manufacturer has to produce test certificate from original producers of raw materials used in the manufacture of the bearings. Irrespective of the producers test certificates, the manufacturer will carry out the detailed tests on raw materials (both physical and chemical) for different types of raw materials used in the manufacture of the bearings as per relevant codes for such raw materials. For this purpose they will identify stock materials with certain batch number and draw samples from such stock materials and mark the same with same batch numbers. For each batch, 3 sets of samples will be drawn separately for tests of physical and chemical properties on samples. The manufacturer will carry out tests on chemical and physical properties on one set of samples and keep the remaining 2 sets of samples duly identified with the batch number for verification by the Engineer and/or his authorized representatives for conformity tests with respect to the results obtained by the manufacturer. Such tests can be carried out on a few samples selected at random by the discretion of the Engineer and/or his representatives. The following IS Codes may be referred for carrying out such tests (both physical and chemical) :

IS:1030 for casting

IS:2062 for Mild Steel Components

IS:2004 for forging

Other special material shall be as per relevant IS/BS/AISI Codes.

11.2.2 All machined cast steel components shall be tested for ultrasonic testing to level III of IS:9565. Critical surface shall also be checked by Dye Penetration Test (DPT) and/or magnetic particle test for detecting presence of surface defects.

11.2.3 All forged steel components after machining will be subjected to ultrasonic testing. Guidelines as per IS:7666 with acceptance standard as per IS:9565 could be referred to. To ensure the reduction ratio, macro-etching test will be conducted on the integral test piece (per heat) attached to anyone of the forging.

11.2.4 All bearing shall be tested to 1.25 times design load. Recovery should be 100 percent. Contact surfaces and welding shall be examined by illumination source/ultrasonic test/DPT for any defects/cracks etc.

11.2.5 All welding shall be checked by Dye Penetration Test. If specially required by Engineer, the X-ray test may also be done.

11.2.6 Engineer may carry out the destructive testing of any component/components of bearings supplied for conformity of test results submitted.

11.2.6.1 In case there is any major discrepancy regarding materials, Engineer may declare the whole lot of bearings as unacceptable.

12 INSTALLATION OF THE BEARINGS

12.1 General Considerations

Bearings are positioned between lower and upper cover plates which are anchored/connected to the sub-structure and super-structure. The cover plates remain fixed to the structure while the bearings are replaced.

12.1.1 The area below bearing shall be levelled by a thin 1:1 cement mortar layer or non shrink pre-packed type (of thickness < 12 mm) just before placing of bearing assembly or bottom plate on the concrete seat. On supporting structures, pockets shall be provided to receive the anchor bolts. Appropriate method for leveling / grouting of the bearing to both beams and pedestal structure shall be adopted. The pocket shall be filled with non-shrink grout.

12.1.2 *Positioning of Bearings*

12.1.2.1 Roller and rocker bearings shall be placed so that their axes of rotations are horizontal and normal to the direction of movement of the members they support, upper and lower bearing plates shall be set horizontal in both directions.

12.1.2.2 During installation the bearings shall be positioned with respect to the bearing axis to account for the movements due to the following :

i) Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.

ii) Shrinkage, creep and elastic shortening.

12.1.2.3 For bridge in gradient the bearing plates shall be placed in a horizontal plane.

12.3 Precautions During Construction

12.3.1 In Segmental construction where launching of girders is employed, it is likely that slipping or tipping of rollers occur due to vibrations or jolts, It is suggested that the roller bearings be provided after launching operations or otherwise adequate measures taken to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings on the launching end and place the beam on the rocker end slightly in advance of placing on the roller.

12.3.2 During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings, and between top plate, saddle plate and base plate in case of a roller-cum-rocker bearing or by any other suitable arrangement which prevents the relative displacement of the components. The bearing plate shall be kept level during concreting.

12.3.3 In pre-stressed pre-cast girders where recesses are left on the underside of girders to receive the anchor bolts, grout holes extending to the beam sides or to the deck level shall be provided. The grout shall have a cement mortar mix of 1:1.

13 INSPECTION, MAINTENANCE AND REPLACEMENT OF BEARINGS

13.1 Inspection

Each bearing assembly and the adjacent members in contact shall be inspected at least once a year by qualified Bridge Inspectors to ascertain their actual condition. A provision for access to the bearings seat on sub-structures shall be made during the design of the bridge for inspection and maintenance.

The following aspects shall be inspected

a) Adequacy for free movement
b) Correct positioning
c) Uncontrolled movements
d) Fracture, cracks and deformations of parts of bearings
e) Cracks in pedestals and in adjacent locations of Sub and Super-structure
f) Condition of anchorage, sliding and rolling surfaces
g) Corrosion of components
h) Seizure due to dust and non-lubrication
i) Special inspection after unusual occurrences like heavy traffic movement, earthquakes, and impacts from floating debris during high floods.

Necessary records of inspection shall be maintained as per standard format

13.2 Maintenance

The bearings shall be cleaned, lubricated and coated with paint after each monsoon season. Provision shall be made for jacking up of the super-structure so as to allow for adjustment repair/replacement of rollers of the bearing.

Suitable remedial measures are taken immediately, if defects are noticed and replacement of bearings done in the event of irreparable damage to any part.

13.3 Replacement

To replace any bearing, the superstructure of the span has to be lifted by one or more hydraulic jacks. Stiffening of diaphragm at the jack point may be needed to prevent splitting tension of concrete. Steel girders may need additional stiffeners. The construction drawings must show the jacking locations, maximum lifting force and the level upto which the deck may be safely lifted. More than one jack would be needed to evenly lift the super-structure. Flat jacks are also used when the clearance between diaphragm and pier/abutment top is less.

The hydraulic jacks have to be equipped with a sliding device if replacement of a bearings takes a long time which result in displacements of moveable bearings. Particular care is required when replacing bearings which transmit horizontal forces. A restraint to the movements is provided by appropriate devices.