STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

SECTION : IX

BEARINGS

PART I : METALLIC BEARINGS
(First Revision)

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

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BEARINGS

Part I : METALLIC BEARINGS

INTRODUCTION

The Standard Specifications and Code of Practice for Road Bridges Section: IX-Bearings-Part I: Metallic Bearings was initially prepared by the Sub-Committee for Bridge Bearings and Expansion Joints and approved by the Bridge Specifications & Standards Committee, Executive Committee and the Council. This was subsequently published as IRC:83-1982 - Part I in December, 1982. The requirement of revising the IRC:83-1982 - Part I to cope up with the technological developments which have taken place in this field of engineering has been felt for quite some time. The first draft revision was prepared by the Technical Committee on Bearings, Joints & Appurtenance during 1991-93 with Shri B.J. Dave as the Convenor. This Committee was reconstituted in January, 1994 consisting of the following personnel :

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The reconstituted Committee discussed the draft during number of meetings held between January, 1994 and January, 1997. The draft was finalised by this Committee after making necessary modifications.

The draft was considered and approved by the Bridge Specifications & Standards Committee at their meeting held at New Delhi on 27.9.97 and approved by the Executive Committee on 29.11.97 and then by the Council in their meeting held on 5.1.98 at Bhopal.

The provisions of this Code shall supersede the following clauses of IRC:24-1967. "Standard Specification and Code of Practice for Road Bridges, Section V: Steel Road Bridges".

Clause Nos. 502.10, 504.7, 504.8, 504.9, 504.10, 504.11, 505.11.2 to 505.11.5 and 508.10, Appendix 1, S.No. 8th and 9th of Table 2 giving reference to clause No. 504.7 and 504.11.

900. SCOPE

This Code deals with the design, manufacture, testing positioning and maintenance of Metallic Bearings on road bridges. The provisions of this Code are meant to serve as a guide to both the 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 code covers longitudinal movement (mainly for monoaxial movement) only, special bearings like spherical bearings are excluded.

901. DEFINITIONS

For the purpose of this Code, the following definitions shall apply:

901.1. Bearings

The part of the bridge structure which bears directly all the forces from the structure above and transmits the same to the supporting structure.

901.2. Sliding Bearing

A type of bearing where sliding movement is permitted between two surfaces, Fig. 1.

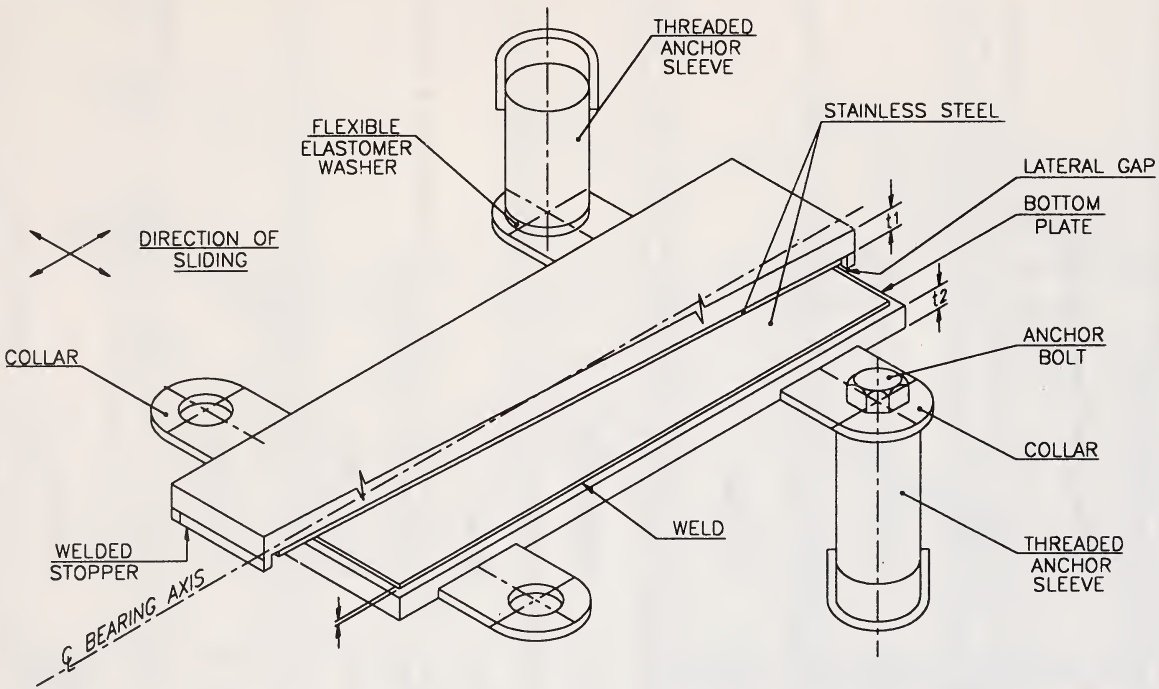


Fig. 1. Sliding Bearing (Typical)

901.3. **Rocker Bearing**

A type of bearing where no sliding movement is permitted but which allows rotational movement, Fig. 2.

901.4. **Sliding-cum-Rocker Bearing**

A type of bearing where, in addition to the sliding movement, either the top or bottom plate is provided with suitable curvature to permit rotation. 'Sliding-cum-Rocker' bearing should conform to General Design Features.

901.5. **Roller-cum-Rocker Bearing**

A type of bearing which permits longitudinal movement by rolling and simultaneously allows rotational movement, Fig. 3.

901.6. **Top Plate**

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

901.7. **Saddle Plate**

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

901.8. **Roller**

A part of bearing which rolls between a top plate and a bottom plate, or between a saddle plate and a bottom plate.

901.9. **Bottom Plate**

A plate which rests on the supporting structure and transmits forces from the bearing to the supporting structure.

901.10. **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.

901.11. **Knuckle**

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

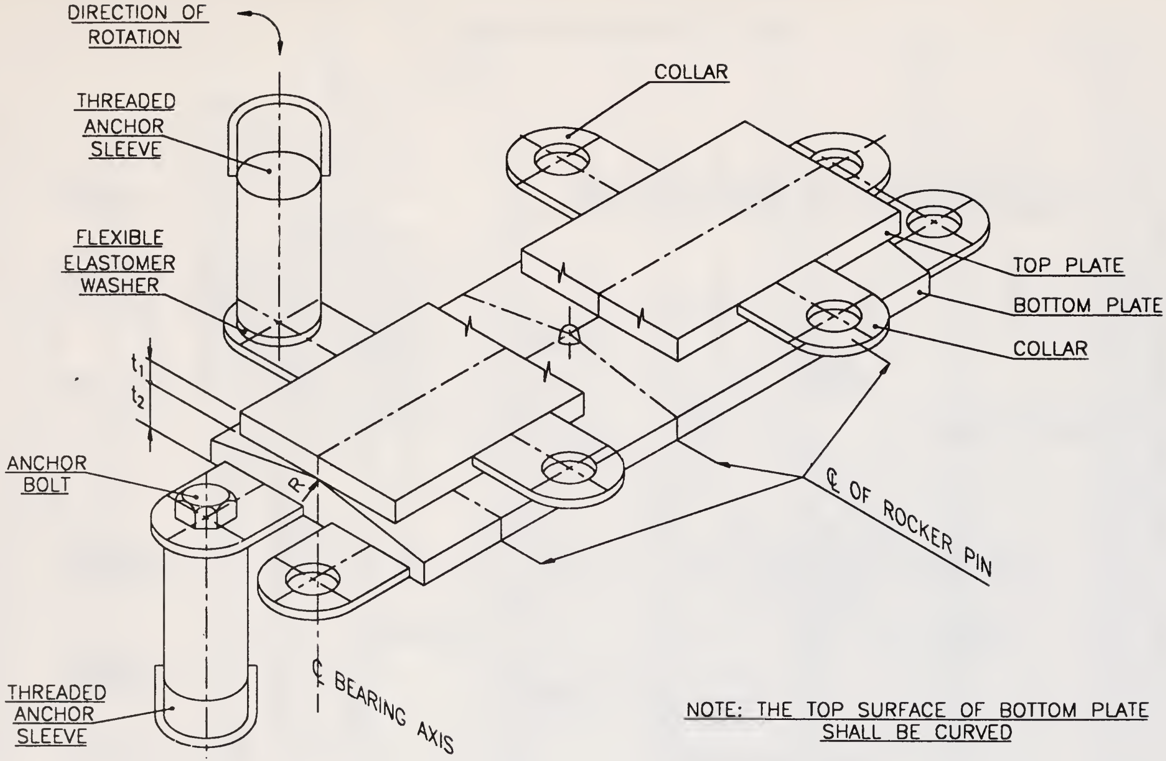


Fig. 2. Rocker Bearing (Typical)

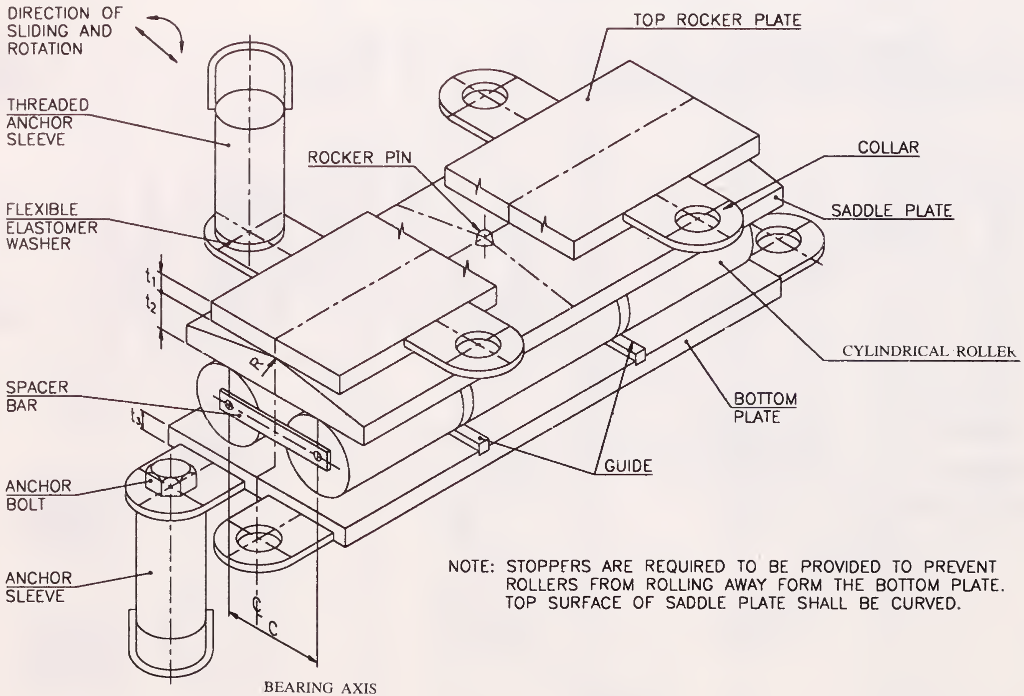


Fig. 3. Roller-cum-Rocker Bearing (Typical)

901.12. **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, Fig. 3.

901.13. **Guide**

A Guide is a device provided to maintain the alignment of the roller during movement.

901.14. **Stopper**

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

901.15. **Anchor Bolts**

A rag bolt or ordinary bolt anchoring the top and bottom plates to the structure.

901.16. **Spacer Bar**

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.

901.17. **Free Support/Free Bearing**

A support/bearing which permits the free relative movement of the parts of the structure.

901.18. **Fixed Support/Fixed Bearing**

A support/bearing which prevents the translational movement of the relative parts of the structure.

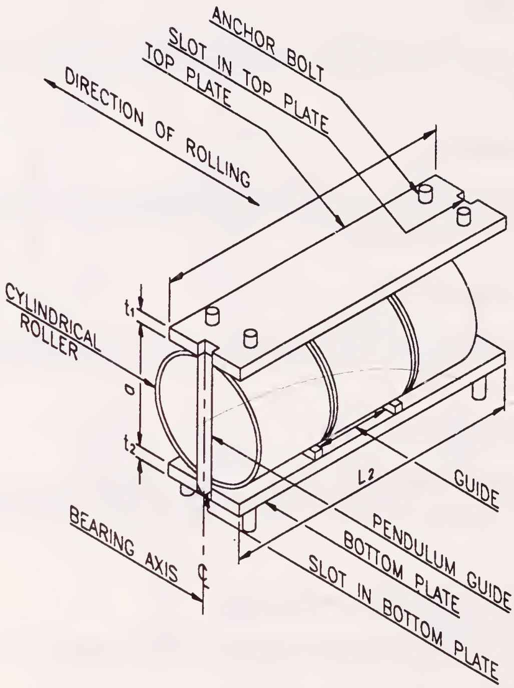
901.19. **Bearing Axis**

The symmetrical axis of the bearing.

901.20. **Effective Displacement**

The total relative movement between the structures in contact with the bearing.

902. TYPICAL ARRANGEMENT OF SLIDING, ROCKER, ROLLER-CUM-ROCKER AND SINGLE ROLLER BEARINGS, SHOWING VARIOUS COMPONENTS OF THE BEARINGS ARE INDICATED IN FIGS. 1, 2, 3, & 4



NOTE: STOPPERS ARE REQUIRED TO BE PROVIDED TO PREVENT ROLLERS FROM ROLLING AWAY FROM THE BOTTOM PLATE.

Fig. 4. Single Roller Bearing (Typical)

903. SPECIAL REQUIREMENTS

903.1. **Roller Bearings**

Only full cylinderical roller is permitted. Adequate width f base plate shall be provided to cater for anticipated movements of the supporting structure.

903.2. **For Seismic Areas (Zone IV and V only)**

The roller and rocker bearing components shall have suitable bearing guides to prevent them from being displaced during earthquakes. The components shall allow for movement as calculated.

903.3. **Skew Bridges**

For bridges with skew angle less than 20^{o} the bearings to be provided shall be placed at right angles to the longitudinal axis of the bridge. For bridges with skew angle greater than 20^{o}, very wide bridges and curved bridges where multi directional movements are expected, special type of bearings are to be provided.

904. MATERIALS AND SPECIFICATIONS

904.1. **Mild Steel**

904.1.1. The mild steel to be used for the components of the bearings shall comply with the following Indian Standards :

i) IS:2062-1992 Steel for General Structural Purposes -Specification

ii) For all components exceeding 50 mm in thickness requiring welding, the carbon contents for such plates shall be ascertained and suitable welding procedure like pre-heating, use of low hydrogen electrodes etc., be adopted after approval.

904.2. **Forged Steel**

904.2.1. 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.

904.2.2. All slabs should be normalised after forging. If welding is involved, and if the slabs are more than 20 mm thick, preheating of the slab upto $200^{o}C$ should be done.

904.3. **High Tensile Steel**

High Tensile steel for bearings shall comply with IS: 961.

904.4. **Stainless Steel**

The stainless steel shall be austenitic Chromium-nickel steel, possessing, rust, acid and heat resisting properties generally as per IS: 6603 and IS: 6911. Mechanical properties/Grade for such stainless steel shall be as specified by the accepting authority but in no case be inferior to mild steel.

904.5. **Cast Steel**

904.5.1. Cast steel used in bearings shall conform to Grade 280-520N of IS: 1030-1989 "Specification of Steel Castings for General Engineering Purposes Specifications". In case where subsequent welding is unavoidable in the relevant cast steel component, the letter N at the end of the grade designation of the steel casting shall be replaced by letter 'W'.

Note : Grade W is difficult to produce in comparison to grade N

904.5.2. For the purpose of checking the soundness, castings shall be ultrasonically examined following procedures as per IS: 7666 with acceptance standard as per IS: 9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS: 1030.

904.6. **Welds**

Welding of steel conforming to IS: 2062, shall be as per IS: 1024, using electrodes as per IS: 814.

905. LOADS AND FORCES

905.1. The loads and forces to be considered in designing bearings for bridges shall be in accordance with the requirements of IRC: 6. Horizontal forces at bearing level shall be as given in Appendix-1.

905.2. The movement of supporting structure shall be assessed and catered for.

906. BASIC PERMISSIBLE STRESSES IN STEEL

906.1. The basic permissible stresses in steel shall be as given in Appendix-2.

906.2. **Basic Permissible Stresses in Stainless Steel**

The basic permissible stresses in stainless steel shall be as specified by the accepting authority, but in no case less than that for mild steel specification Clause 906.1.

906.3. **Basic Permissible Stresses in Concrete in Contact with Bearings**

The basic permissible stresses in concrete shall be as specified in IRC: 21.

906.4. **Allowance Working Stresses in Welded Joints**

906.4.1. The allowable working stress shall be based on the following stresses :

i) Butt Welds - 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.

ii) Fillet Welds - The permissible stress in fillet welds based on its throat area shall be 110 MPa.

iii) Plug Welds - The permissible shear stress on plug welds shall be 110 MPa.

906.4.2. Where welds are not subjected to radiographic or any other equally effective methods of testing, but the accepting authority is otherwise satisfied with the quality of work, the allowable working stress specified in Clause 906.4.1 shall be multiplied by a factor of 2/3.

906.5. **Allowable Working Loads on Cylindrical Roller Bearings**

(Length of rollers worked out on the basis of formulas given below shall be exclusive of width of groove.)

906.5.1. **Cylindrical rollers on a flat surface** : The allowable working load for a single or double roller in Newton per mm length of roller shall be as follows :

Roller material	Flat surface material		
	Cast Steel	Forged Steel	Mild Steel
Cast Steel	11 d	11 d	8 d
Forged Steel	11 d	11 d	8 d
Mild Steel	Mild steel rollers are not permitted		

where d is the diameter of the roller in mm

For three or more rollers the values of working load shall be two-thirds of the above mentioned values.

The basic formula for allowable working load in Newton per mm length of roller for single or double roller is

$$\frac{9\,d\,\sigma_U^2}{E}$$

where σ_U = Ultimate tensile strength of the softer material in N/mm^2

E = Modulus of elasticity of steel in N/mm^2

The allowable working load when both the roller and the mating surface are of high tensile steel or any other high grade steel may be found out using the above relationship.

906.5.2. **Cylindrical rollers on a curved surface** : The allowable working load for a single or double roller in Newton per mm length of roller shall be as follows :

Roller material	Curved surface material		
	Cast Steel	Forged Steel	Mild Steel
Cast Steel	$11(dd_1)/(d_1-d)$	$11(dd_1)/(d_1-d)$	$8(dd_1)/(d_1-d)$
Forged Steel	$11(dd_1)/(d_1-d)$	$11(dd_1)/(d_1-d)$	$8(dd_1)/(d_1-d)$
Mild Steel	Mild steel rollers are not permitted		

Where, d is the diameter of the roller in mm

d_1 is the diameter of the concave surface in mm

For three or more rollers the values of working load shall be two-third of the above mentioned values.

The basic formula for allowable working load in Newton per mm length of roller for single or double roller is

$$\frac{9dd_1\,\sigma_U^2}{E\,(d-d_1)}$$

906.5.3. **Spherical or cylindrical knuckle** : The basic permissible pressure shall not exceed 120 N/mm^2. The working pressure shall be calculated on the projected area of the mating surface.

907. DESIGN CONSIDERATIONS

907.1. General

907.1.1. The bearings shall be designed to withstand the maximum vertical reactions and longitudinal force under the most critical combination of loads and forces. Provision shall also be made against any uplift to which the bearings may be subjected under the action of the above forces.

907.1.2. The allowable bearing pressure on the loaded area o a base under a bearing shall be given by Clause 307 of IRC: 21.

907.1.2.1. The loaded area shall be calculated as below :

i) For plates with rocking line of contact the width shall be the available dispersed width (max. dispersion being limited to 2 horizontal to one vertical).

and

ii) For plates with rolling lines of contact the width for any particular position shall be the centre to centre distance of outermost rollers plus the available dispersed width beyond the outermost lines of contact (max. dispersion being limited to 2 horizontal to one vertical).

907.1.3. Where the eccentricity of loads and longitudinal forces are considered alongwith direct compressive forces, the calculated direct bearing stress and the flexural stress, shall satisfy the following equation :

$$\frac{\sigma c_0, cal}{\sigma co} + \frac{\sigma c, cal}{\sigma c} \leq 1$$

Where, $\sigma c_0, cal$ = the calculated direct bearing stress
σc_0 = the allowable direct bearing stress as per clause 907.1.2.
$\sigma c, cal$ = the calculated flexural stress
σc = the permissible flexural stress in concrete or σc_0 whichever is higher.

907.2. Rocker and Roller-cum-Rocker Bearings

907.2.1. Top, saddle and bottom plates

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

907.2.1.2. 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 siting. (The centre to centre distance of outermost rollers if these are two or more. For single roller bearings it shall be taken as zero), see Fig. 5.

907.2.1.3. 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.

907.2.1.4. 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 906.

907.2.2. Rollers

907.2.2.1. Forged steel rollers may be preferred over cast steel rollers, Mild Steel rollers shall not be used. The minimum diameter of roller shall be 75 mm.

907.2.2.2. The ratio of the length of the roller to its diameter shall normally not be more than 6.

907.2.2.3. The effective contact length with the plate shall be used for arriving at the length of the rollers to be used in the formula given in Clause 906.5.

907.2.2.4. The gap between the rollers shall not be less than 5C mm in case of multiple rollers.

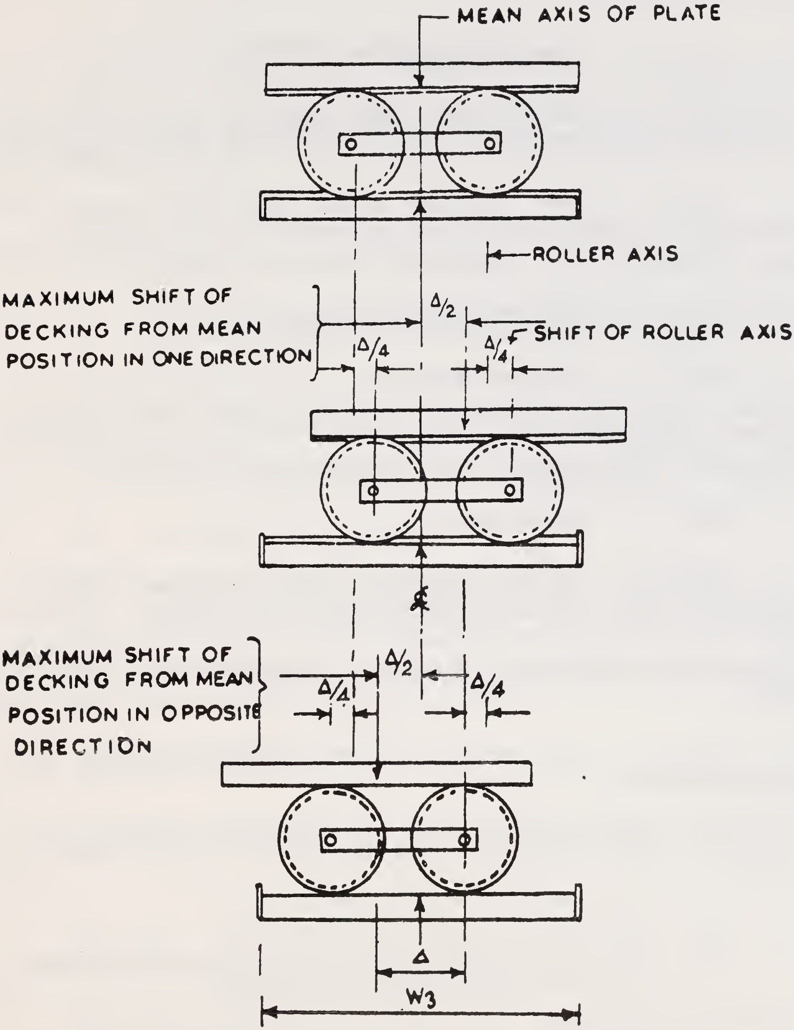


Fig. 5 . Maximum Shifts of Top Plate and Rollers due to Movements of Deck

The minimum width of various plates shall be calculated from the following formulae (Clause 907.2.1.2)

W_1	$\geq$	100 or $2t_1$ whichever is greater
W_2	$\geq$	100 or $[(n-1)\,C + 2\Delta]$ or $[(n-1)\,C + 2t_2]$ whichever is greatest
W_3	$\geq$	100 or $[(n-1)\,C + 2\Delta]$ or $[(n-1)\,C + 2t_3]$ whichever is greatest
Δ	=	Effective displacement
n	=	No. of roller
		t_1, t_2 and t_3 as in, Fig. 3

907.3. **Sliding Bearings**

907.3.1. The top plates shall project on all sides over the bottom plate by atleast 10 mm for any extreme position of the bearing.

907.3.2. The thickness of the plate shall satisfy the requirements of structural design and permissible stresses laid down in Clauses 906 and 907.2.1.4, but shall not be less than 20 mm.

907.4. **Miscellaneous Components**

907.4.1. **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 the value specified in Clause 906.

907.4.2. **Rocker pin**

907.4.2.1. 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.

907.4.2.2. 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.

907.4.3. **Spacer bars** : To ensure movement of multiple rollers in unison, spacer bars may be provided but the arrangement shall be such that the rollers can rotate freely, Fig. 3.

907.4.4. **Guide lugs and grooves**

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

907.4.4.2. 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 10mm.

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 top of the guide lug.

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

907.4.6. **Anchor bolts**

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

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

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

907.4.7. **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.

907.4.8. **Pendulum guides** : An arrangement with slots to prevent the displacement of the roller unit due to siesmic or other dynamic vibrations shall be provided. An example of such an arrangement is shown in, Fig. 4.

908. WORKMANSHIP AND TOLERANCES

908.1. 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.

908.2. **Plates**

908.2.1. 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.

908.2.2. All rolling, rocking and sliding surfaces shall have a machine smooth finish to 20 micron maximum mean deviation as per IS:3073.

908.3. **Rollers and Curved Surfaces**

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

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

908.4. **Castings**

908.4.1. 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.

909. ACCEPTANCE CRITERIA AND TESTING

909.1. **Acceptance Criteria** : Unless agreed upon otherwise between the Engineer and the Manufacturer, the Manufacturer shall furnish a complete Quality Assurance Programme (QAP) 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 programme 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 programme. 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 Programme.

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

909.1.1. 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.

909.1.2. All casting and forgings shall be annealed/normalised 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.

909.1.3. 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 MT capacity

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

iv) Ultrasonic flaw detector

v) Metalography for checking of microstructure of different materials

vi) Load testing machine of required capacity having facilities of rotation and lateral loading.

909.1.4. 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.

909.1.5. Bearing manufacturer shall employ full time sufficient graduate Engineering staff for manufacture and quality control of bearings and shall have full time trained Scientist in chemical and physical testing and also have qualified person for ultrasonic testing.

Bearing manufacturer shall have qualified/certified welders.

909.2. **Testing**

909.2.1. 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 authorised representatives for conformatory 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 materials shall be as per relevant IS/BS/AISI Codes.

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

909.2.3. All forged steel components after machining will be subjected to ultrasonic testing. Guidelines given in Appendix-3 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.

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

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

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

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

910. PLACING AND POSITIONING THE BEARINGS

910.1. General Considerations

910.1.1. On supporting structures, pockets shall be provided to receive the anchor bolts. Appropriate method for levelling/grouting of the bearing to both beams and pedestal structure shall be adopted. The pocket shall be filled with mortar of mix 1:1 and the concrete bearing area also shall be finished level by a thin mortar pad of mix 1:1 just before placing of bearing assemblies or bottom plate on the concrete seat.

910.2. Positioning of Bearings

910.2.1. During installation the bearings shall be pre-set 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.

910.2.2. For bridges in gradient the bearing plates shall be placed in a horizontal plane.

910.3. **Precautions during Construction**

910.3.1. In prestressed construction where launching of girders is employed, in order to avoid slipping or jumping of rollers 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.

910.3.2. 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.

910.3.3. 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 mix of 1:1.

911. INSPECTION, MAINTENANCE AND REPLACEMENT OF BEARINGS

911.1. Suitable easy access to the bearing shall be provided for inspection and maintenance.

911.2. Provision shall be made for jacking up of the superstructure so as to allow for adjustment repair/replacement of rollers of the bearings.

911.3. Each bridge bearing assembly and the adjacent members in contact shall be inspected at least once a year to ascertain their actual condition and suitable remedial measures taken immediately if defects are noticed including replacement in the event of irrepairable damage. However, the bearings shall also be examined carefully after unusual occurrences like heavy traffic damage, earthquakes, and batterings from debris in high floods. Necessary records of inspection shall be maintained.

Appendix-1
(Clause 905.1)

HORIZONTAL FORCES AT BEARING LEVEL

The design horizontal forces at the bearings shall be the maximum of the following combination :

(1) **For simply supported bridge with a fixed and free bearing (other than elastomeric type on stiff supports)**

Fixed Bearing	Free Bearing
(i) Fh-μ(Rg+Rq) or (ii) Fh/2+μ(Rg+Rq) whichever is greater.	μ(Rg+Rq)

Where :

Fh = Braking or seismic force* on the length of decking effective for the bearing

Rg = Reaction at the free end due to dead load

Rq = Reaction at the free end due to live load

μ = Coeff. of friction at the movable bearings, which shall be assumed to have the following values :

(a) For Steel Roller Bearings - 0.03
(b) For Sliding Bearings :
  (i) Steel on Steel or cast iron - 0.5 (unless otherwise proved by tests or other supporting data)
  (ii) Meehanite and Grey Iron Castings on similar metal - 0.40

In seismic areas, the fixed bearing shall also be checked for full seismic force.

(2) **Slab type bridges of span less than 10 m**

The force at the bearing shall be Fh/2 or μRg whichever is greater.

Where :

Rg = Reaction due to Dead Load on the bearing

Note : *The component in the direction of traffic of seismic or wind force on the structure caused by the live load, need not be considered along with braking force.

(3) Continuing Bridge with one fixed bearing and other free bearings (other than elastomeric type on stiff supports)

Fixed Bearing	**Free Bearing**
Case I	
$(\mu R-\mu L)$ + ve and Fh acting in + ve direction	
(a) If $Fh>2\,\mu R$	
$Fh-(\mu R+\mu L)$ - - - - - - -	$\mu\, Rx$
(b) If $Fh<2\mu R$	
$\dfrac{Fh}{1+\Sigma n_R} - (\mu R-\mu L)$	
Case II	
$(\mu R-\mu L)$ + ve and Fh acting in — ve direction	
(a) If $Fh>2\,\mu L$	
$Fh-(\mu R+\mu L)$ - - - - - - -	$\mu\, Rx$
(b) $Fh<2\mu L$	
$\dfrac{Fh}{1+\Sigma n_L} - (\mu R-\mu L)$	

whichever is greater

where

μ_L or n_R = number of free bearings to the left or right of fixed bearings, respectively.

μL or μR = the total horizontal force developed at the free bearings to the left or right of the fixed bearing respectively.

μRx = the net horizontal force developed at any one of the free bearings considered to the left or right of the fixed bearings.

Appendix-2
(Clause 906.1.)

PERMISSIBLE STRESSES

Table 1. Basic permissible stresses in MPa in members i.e. plate, flats, squares, rounds etc. other than rocker pin, knuckle pin, anchor bolts, screws, etc.

S.No	Description	High Tensile IS:961-1975 or sp steel	Cast Steel IS:1030-1989	Forged Steel IS:2004-1978	Mild Steel IS:226-75/ 2062-84
1.	Max. axial tensile stress on effective sectional area (σy^{t})	0.60 σy,	160	160	140
2.	Max. bending tensile or compressive stress on effective sectional area for extreme fibre ($\sigma t/\sigma c$)	0.66 σy,	180	180	150
3.	Max. shear stress (τ ra)	0.45 σy,	120	120	105
4.	Max. bearing stress on non-sliding surface (σp)	0.80 σy,	215	215	186
5.	Max. combined bending shear & bearing, stress (σbc)	0.92 σy,	250	250	210

Table 2 . Permissible stress in MPa in knuckle pin, rocker pin

S.No.	Description	High Tensile IS:961-1975 or sp steel	Cast Steel IS:1030-1989	Forged Steel IS:2004-1978
1.	Max. axial tensile stress on effective sectional area (σyt)	0.60 σy,	160	160
2.	Max. shear stress (τra)	0.37 σy,	100	100
3.	Max. bearing stress on non-sliding surface (σp)	0.87 σy,	235	235

Table 3. Permissible stresses in MPa in anchor bolts and screws

S.No.	Description	Black Bolts conforming to property Cl.4.6 of IS:1367-1967	
1.	Max. axial tensile stress (σt)	120	Permissible stresses in a bolt of any other property class will be as per Cl. 8.9.4.3 of IS:800-1984 which is reproduced below for convenience:
2.	Max. shear stress (τra)	80	
3.	Max. bearing stress (σyt)	250	"The permissible stress in a bolt (other than a high strength friction grip bolt) of property class higher than 4.6 shall be those given in Table 8.1 multiplied by the ratio of its yield stress or 0.2 per cent proof stress or 0.7 times its tensile strength, whichever is the lesser to 235 MPa."

Note : Components of bearings should be designed for the worst combination of loads with no increase in permisible stresses.

Appendix-3
(Clause 909.2.3)

GUIDELINES REGARDING PROCEDURE FOR ULTRASONIC TESTING OF FORGED STEEL ROLLERS CONFORMING TO IS:2004 CLASS 3 AND ITS ACCEPTANCE STANDARD

Type of Equipment	Krantakrammer/ECIL/EEC or Vibronics make ultrasonic flow detector
Test Method	Pulse echo direct contact method
Test	2-2.5 MHz, 24 mm
Frequency Probe	Straight beam (normal) probe
Size Couplant	Oil/Grease
Text	Scanning by hand probing
Direction	Throughout the length of the body of forged proof-machine rollers in all possible direction at least covering the surface area upto 180^{o}.
Calibration	Calibration of the machine (UFD) is to be done using IIW block/standard calibration block for a range of 2.00 mm.
Sensitivity setting	The sensitivity shall be set on a 3.0 mm dia. Flat bottom (FB) hole drilled upto a depth of 25 mm on a 200 mm length x 10 mm dia. Class 3 forged bar having reflection of screen height of 75% from the FB hole.
Acceptance Standard	i) Forged rollers shall not contain harmful defect like shrinkage, cavities, porosities, piping cracks etc. Any type of surface crack is not acceptable.
	ii) Flaw signal more than 70% height at one location shall be a cause for rejection in case the flaw is along the central axis zone of the roller (i.e. 12.0 mm either side of the axis line).

iii) Flaw signals equal or more than 50% height shall be a cause of rejection in case two consecutive flaw echos are within 200 mm distance at the central axis zone.

iv) At no point the length of the central axis zone defect shall exceed 2 probe position.

v) The defects so detected, shall not be spaced less than 200 mm at the roller ends (within 100 mm).

vi) Total number of defects shall not exceed 3 in one roller.

vii) Connected discontinuities shall not be permitted.