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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

GUIDELINES FOR SELECTION OF BRIDGE BEARINGS FOR RAILWAY BRIDGES & ROBs

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Guidelines for Selection of Bridge Bearings for Railway Bridges & ROBs

1.0 Introduction:

1.1 This document contains the broad guidelines for selection of bridge bearings for railway bridges & ROBs on Indian Railways from design and maintainability considerations. This guideline is prepared on the basis of literature survey from following codes, manuals, reports, papers, literature, etc.

1. AASHTO LRFD Bridge Design Specifications 2012
2. Publication No. FHWA-HIF-16-002 - Vol. 15
3. AASHTO/NSBA Steel Bridge Collaboration G 9.1 – 2004: Steel Bridge Bearing Design and Detailing Guidelines.
4. SCI P 185: Guidance note on best practices in steel bridge construction.
5. Design guide for bridges for service life: Transport Research Board, Washington DC.
6. Development of guide specification for service life design of highway bridges: NCHRP, USA
7. IRC-83 (Part 2, Part 3 and Part 4)

1.2 These guidelines are prepared for helping the field engineer. These guidelines are just to facilitate and not to supersede any of the provisions of original documents. In case of any difference in this document and the above-mentioned documents or any codes/manuals etc, the provisions in the original documents shall prevail.

2.0 Main functions of bridge bearings are as under:

(a) Transfer of vertical loads

(b) Allowing rotation of Girders

(c) Transfer of lateral/ longitudinal loads

(d) Allowing certain movements

(e) Restricting certain movements

3.0 Main types of bridge bearings used in Indian Railways and their characteristics:

3.1 Following four main types of bearings are generally used on Indian Railways

a) Steel Bearings- Sliding bearing and Rocker & roller bearings.

b) Steel Reinforced Elastomeric bearing

c) Pot-PTFE Bearing

d) Spherical Bearings with high density polymer at sliding interface

Characteristics of a particular type of bearing should be considered while selecting the bearings for a particular type of bridge span.

3.2 The main materials used for bridge bearings are Steel, Elastomer (Chloroprene and Isoprene) and High-Density Polymer (PTFE). Each of these materials has its own advantages and disadvantages with respect to load bearing capacity, deformability, and frictional resistance at interface etc. A bearing can be made of single material or a combination of more than one material.

3.3 Traditionally steel is the most preferred material used for bridge bearings for steel superstructures. In **steel sliding bearings**, lug connected with the girder rests over a bed plate anchored to the sub-structure. The bearing lugs are provided with chamfering so that the rotation of the girders can be accommodated and the expansion/contraction of girders can be accommodated by linear movement of the lug sliding over the bed plate. In **steel roller rocker bearings**, the rockers are provided on both ends which accommodate the rotation of girders under load. One end of the girder is fixed and the other end is provided with rollers. Only one end of the girder which is having rollers can move to accommodate the expansion/contraction of the girder. There are other types of steel bearings including pendulum bearings which are used in some special bridges (including the old Jubilee Bridge) and bearings with phosphor bronze plate which were used in under slung girders of 30.5 m span. Another variation of the roller bearings is with oil bath which are provided in long spans or where the greasing is difficult to be carried out.

The **Elastomeric bearing** is most widely used with concrete superstructures and now a days with steel-concrete composite superstructures. Linear displacement is achieved by shear strain in elastomer pad. The rotation is achieved in elastomeric bearings by differential compression of elastomer.

Modern materials like **PTFE** etc. having quite small frictional resistance with stainless steel, is used where relatively large linear displacement is required. In **POT-PTFE bearings**, linear displacement takes place with stainless steel surface sliding over PTFE sheets wherein the coefficient of friction is almost the same as for the roller bearings. In this case, the elastomer confined in the “pot” acts like a pressurized fluid and any rotation of structure is accommodated in the differential compression of the same.

Another category of bearing is **Spherical bearing** which has come in vogue recently. The rotation achieved by incurve sliding of mating spherical surfaces in spherical bearings and linear displacement is achieved by sliding of plate with stainless steel over PTFE.

3.4 Characteristics of various types of bearings:

A. Steel Bearings: Sliding and Roller-Rocker

Pros:

1. These are one of the oldest bearing types being used in bridges of Indian Railways. Proper know how and knowledge of fabrication, inspection and maintenance is available with Indian Railways for using such type of bearings including the knowledge of maintenance and repair.
2. Sliding bearing is suitable for spans upto 30 m while roller and rocker are suitable for spans greater than 30 m.
3. Steel bearings can be fabricated by the steel girder fabricators and no special machinery or factory/ technology is required for their fabrication. It is one of the simplest forms of bearing.
4. Steel bearing are very robust and can give service life equal to girder life.
5. These bearings are made up of material similar to that of girder and require similar maintenance as that of the steel girders.
6. Height of sliding bearing is very less as compared to bearing which are used on span of similar length.

Cons:

1. Conventionally Steel bearings are used mostly with steel girders and very rarely used with concrete girders.
2. Maintenance requirement is more as compared to other types of bearings.
3. It requires periodical cleaning, oiling, and greasing to reduce friction and proper functioning.

4. Corrosion of steel bearing is problem in corrosion prone areas. Although the life of steel bearings may be considered same as that of bridge girder life but this may be reduced, if not maintained properly in corrosion prone areas.
5. Steel sliding bearings has a higher coefficient of friction, and if the size of bearing lug is small, then load concentration can take place which can lead to problems in bed block as well as loosening of holding down bolts.
6. Maintainability of roller bearings can be improved by using oil bath arrangement, but periodic replacement of oil is required along with periodic greasing of the rocker element.
7. Height of roller-rocker bearings is more as compared to bearing which are used on span of similar length.

B. Steel Reinforced Elastomeric Bearings:

Pros:

1. It is suitable for short to medium spans (generally up to 35 m) with moderate load and rotation requirement.
2. These bearings can be used for longer spans also. However, for longer spans these bearings may have to be designed as Fixed-Free type combination rather than Free-Free type combination.
3. It is flexible to accommodate minor structural deviations / irregularities.
4. It is robust bearing with minimal problems and minimum need for maintenance when properly designed, manufactured, and installed.
5. Reinforcing Steels are enclosed in Elastomer, therefore protected against corrosion
6. These bearings are low cost.
7. These bearings are easily inspectable during service. It is having no hidden parts. Any flaw or defect in bearing is easily identified.
8. It is having good seismic performance in low to moderate seismic activity. In Higher seismic zones, these can be designed with seismic restrainers or guided bearings for better seismic performance
9. It accommodates multidirectional movement and rotation. It is well suited for cases in which transverse movements are uncertain.
10. Circular shape of these bearings is ideally suited for skew spans.
11. It has good damping characteristics. It is effective in equitable dispersion of forces

especially the longitudinal forces in comparison to other bearings.

Cons:

1. It is not suitable for longer spans with higher load, rotation and movement requirements.
2. Elastomeric bearings require minimum vertical load of 2 MPa for proper functioning. Where the vertical load is less, say in steel plate girders, anti-slip devices are required to be used
3. Defects arising from poor product quality such as inadequate vulcanization, lack of bond between laminate and elastomer, poor rubber quality etc. leading to splitting, slippage, bulging and cracking of the rubber.
4. Generally, bearings of larger plan dimensions are more prone for defects such as inadequate vulcanization and lack of bond between laminate and elastomer.
5. Errors in dimensioning, that leads to laminates being too short and of insufficient area.
6. Isoprene (natural rubber) have less resistance to ozone degradation, but problem of ozone degradation is not an issue with Chloroprene rubber. Use of bearings fully made of natural rubber which is susceptible to ozone degradation should be avoided.
7. It may have freezing and stiffening problem of the rubber at low temperatures. However, adopting higher value of shear modulus in design can take care of stiffening issue.

C. POT-PTFE Bearings:

Pros:

1. It is suitable for higher loads and longer spans with requirement of higher vertical load capacity and large rotations. Pot bearings can be easily designed for rotation upto 0.04 radians with no restriction on horizontal movement.
2. Individual components (mainly rubber disc) can be replaced to get the desired performance instead of changing the whole bearing.
3. It distributes loads uniformly through the structure as a result of hydrostatic pressure developed in the elastomer.

Cons:

1. Size of the bearing can be large for higher loads due to limited capacity of the Elastomer. Consequently, larger space is needed for installing these bearings on Pier Caps in

comparison to Spherical bearings.

2. It requires high precision in fabrication and Installation.
3. Life of internal seal generally determines the life of these bearings. Most of the problems associated with these bearings are relating to squeezing out of elastomer due to breaking of internal seal.
4. It may result in limited rotation capacity due to ageing of Elastomer in long run.
5. With the natural restoring moment of the elastomeric pad combined with relatively small vertical load, a gap at the sliding area occurs at one side. Meanwhile, the opposite side has to accommodate high edge stresses.
6. Amenability to inspection of critical bearing components is not good as most of the parts are not visible from outside.
7. Periodical cleaning of area around bearing to prevent ingress of dirt, dust etc.
8. Improper design and manufacturing may result in leakage of elastomer, broken sealing rings, abraded elastomeric pads, and internal metal to-metal contact.
9. This has internal moving parts and requires a high degree of Quality Control in manufacturing.
10. Surface damage of sliding PTFE material caused by contamination. This hampers the sliding capability of bearing and increases the friction between sliding surface. In extreme cases it may cause metal to metal contact due to total wear of PTFE.
11. Exposed cast iron POT and other surfaces are prone to corrosion especially in corrosion prone areas and bearing life is reduced in such cases.
12. For providing POT-PTFE bearings on open web girders adequate stiffening of bottom chord is required.
13. The initial rotation of bottom chord due to camber under dead load in OWG also need to be suitably compensated to ensure uniform load transfer on horizontal bearing surface.

D. Spherical Bearings with High density polymer like PTFE or similar material at interface:

Pros:

1. It is suitable for structures supporting high vertical loads, frequent high displacements from traffic and for structures that requires fast bearing movement such as bridges for high speed railways and bridges of very long spans.

2. Easy to install and can be easily replaced.
3. Limited maintenance is required for these bearings.
4. It allows greater rotation compared to pot bearings which makes it suitable for bridges subject to large turning angles and high torsion forces such as wide and curved bridges.
5. It does not use elastomer or rubber hence there is no problem of rubber aging affecting the rotation of the bearing.
6. It is suitable for low degree temperature even for temperatures as low as -50°C.

Cons:

1. It may be relatively expensive due to high level of precision required in fabrication. However, as a proportion of cost of the bridge the additional cost incurred would be negligible.
2. Spherical Bearings require very high precision in machining and finishing with very low tolerances, otherwise it will degrade fast.
3. Fixing PTFE or similar material on curved engraved surface require very high skill and high precision machinery.
4. As these bearings are very stiff in vertical direction, high level of accuracy is required in installation to avoid secondary stresses in torsionally stiff superstructures like Box girders.
5. Wear of PTFE may reduce the anticipated life of bearings. However, use of better sliding materials such as ultra-high molecular weight Poly-Ethylene (UHMWPE) or any other superior material may give better performance.
6. For providing Spherical bearings on open web girders adequate stiffening of bottom chord is required.
7. Periodical cleaning of area around bearing is required to prevent ingress of dirt, dust etc.

4.0 Suitability of various bearings according to functions:

Suitability of four bearing types mentioned above in para 3 above is given in Table 1.

Table 1: Suitability of Bearings

Bearing Type	Load and Movement Performance Values				Durability Factors			Avoidance or Mitigation Requirements	Life-cycle Costs		Service Life Potential
	Load (T) #	Rotation (radians) @	Movement (mm) $	Multidirectional Rotation/ Movement Capability	Relative Ability to Accommodate Cyclic loads and Movement	Resistance to Corrosive Environment	Resistance to Production/ Operation Defects		Relative Initial Cost A=Lowest	Relative Maintenance Cost	
Fabricated steel (pin fixed, rocker or roller)	Low to medium (Up to 265)	High No Limit	High No Limit	No	High	Low for all elements	High	Use stainless steel or mitigate with galvanizing or metalizing Use oil bath	B	Moderate however Low with SS	High for less corrosion prone areas. Moderate for corrosion prone areas.
Steel reinforced elastomeric pad	Low to medium (30 to 220)	Medium 0.02	Low to Medium 60	Yes	High	High	High	Proper Quality control to avoid manufacturing defects and ensure proper installation	A	Low	High
POT PTFE Bearing	High (20 to 1780)	High upto 0.04	High No limit	Yes	Low due to wear of sliding surface	Moderate for exposed sides of POT and Piston	Moderate-Internal sealing ring wear and elastomer leakage	Ensure proper quality control during manufacturing, Improved sliding surface and Metalized surfaces for corrosion protection of exposed surfaces	C	Moderate	Moderate

Bearing Type	Load and Movement Performance Values				Durability Factors			Avoidance or Mitigation Requirements	Life-cycle Costs		Service Life Potential
	Load (T) #	Rotation (radians) @	Movement (mm) $	Multidirectional Rotation/ Movement Capability	Relative Ability to Accommodate Cyclic loads and Movement	Resistance to Corrosive Environmen t	Resistance to Production/ Operation Defects		Relative Initial Cost A=Lowest	Relative Maintenance Cost	
Spherical	High (20 to 1780)	High No Limit	High No Limit	Yes	Low due wear of sliding surface	Moderate for exposed sides of steel elements	Moderate. PTFE Wear. Surfaces not mating properly.	Proper design and construction. Improved sliding surfaces. Metalized surfaces.	D	Moderate	Moderate

The load capacity mentioned is indicative and for general cases. The load capacity of the bearings is basically determined by the strength of the constituent materials of the bearing, structure of the bearing and the load bearing capacity of the interfaces with superstructure and substructure. There may be incidences where this limit may exceed for specially designed bearings for special type of bridges.

@, $ The rotation and movement capacity of bearings mentioned above is also indicative and for general cases. There may be incidences where this limit may exceed for specially designed bearings for special type of bridges.

5.0 Suggestion for selecting bearings:

Based on above, suggested use of various bearings for different types of spans of railway bridges and ROBs being used over Indian Railways is given in Table 2. Important aspects which are required to be considered while choosing a bearing type for particular bridge are as under:

a) Reliability of bearing performance is more important than the cost and maintenance requirements.

b) The quality of bearings should be excellent. These small parts transfer the entire load coming to the girder to the substructure and perform critical functions which allow the structure to function as assumed in the design.

c) The cost of bearings is quite less as compared with the overall cost of bridge. Typically, bearings cost less than 2% of the cost of bridge. Any problem with bearings will create problems in the girder and/or substructure, which will be very costly to repair.

d) Bearings with lesser maintenance are preferable over bearings requiring higher maintenance.

e) It is preferable to choose a bearing which has life equal to or more than the life of girders so that trouble free life of bridges is assured.

Table 2: Suggested bearing types for particular Girder types

SN	Girder Type	Suggested Bearing Types
1	Steel Plate Girder (Railway Bridge) for spans upto 24.4 m.	1. Steel sliding bearing in less corrosion prone areas. For use in corrosion prone areas suitable corrosion mitigation measures to be done. 2. Steel reinforced elastomeric bearing with anti-slip devices.**
2	PSC Girder (Railway Bridge) for spans upto 24.4 m. span	1. Steel reinforced elastomeric bearing 2. POT-PTFE bearing
3	Steel Concrete Composite I Girder (Railway Bridge) for spans upto 30.5 m.	1. Steel reinforced elastomeric bearing

SN	Girder Type	Suggested Bearing Types
4	Steel Open Web Girder open deck type (Through as well as underslung girder) for spans 30.5 m. and above	1. Steel Rocker and Roller bearing in less corrosion prone areas. For use in corrosion prone areas suitable corrosion mitigation measures to be done. 2. Spherical bearing with PTFE or similar material at sliding interface. Suitable corrosion mitigation measure for exposed portion of bearing in corrosion prone area should be done.
5	Rail cum Road Bridges	1. Spherical bearing with PTFE or similar material at sliding interface. Suitable corrosion mitigation measure for exposed portion of bearing in corrosion prone area should be done
6	Steel Concrete Composite I Girder (ROB) for spans upto 36 m.	1. Steel reinforced elastomeric bearing 2. POT-PTFE bearing. Suitable corrosion mitigation measure for exposed portion of bearing in corrosion prone area should be done.
7	Bow String Girder (ROB) for spans 42 m. or more	1. Spherical bearing with PTFE or similar material at sliding interface. Suitable corrosion mitigation measure for exposed portion of bearing in corrosion prone area should be done. 2. POT-PTFE bearing. Suitable corrosion mitigation measure for exposed portion of bearing in corrosion prone area should be done

Notes:

1. The bearing chosen should be compatible with the design loads, horizontal movement and rotation. The above suggestion is indicative only and decision regarding the use of particular bearing should be done on the basis of site and design requirements and ability of a particular bearing to fulfill those requirements.

2. The type of girders given in Table 2 above are based on types which are typically being used for a particular span length in standard drawings of RDSO at present. There might be instances when other type of girder might be used for span length range indicated in above table due to site requirement or any other requirement. In such cases the decision of suitable bearing should be done accordingly.

3. **Steel sliding bearing should not be replaced by elastomeric bearing in existing spans where already sliding bearing is there. Elastomeric bearing should be provided in cases of construction/replacement of superstructure.

4. The life of POT-PTFE and Spherical bearings depend upon the life of sliding materials which is stipulated in terms of Accumulated Sliding Path (ASP). ASP can be calculated based upon current and projected traffic, and the life of bearing can be assessed accordingly. This issue is likely to govern selection of bearings for long span bridges.

5. Above suggestions are only recommendatory. Due diligence shall be carried out for selection of suitable type of bearing for a particular bridge.

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