ASHGHAL

Interim Advice Note No. 006

Specification for Bridge Bearings

Revision No. A1

EXW-GENL-0000-PE-KBR-IP-00006

Summary
This Interim Advice Note (IAN) provides information and guidance on the specification to be adopted for bridge bearings. This IAN takes immediate effect. The following shall be noted:

- This IAN does not make any amendments to the existing Qatar Construction Specifications (QCS) 2010.
- This IAN adds a new Section and new Part to QCS 2010, namely Section 101, Part 3, Bridge Bearings.

This document supersedes IAN 006 Rev 0 dated February 2013. Third parties not working on Ashghal projects make use of this document at their own risk. Paper copies of this document are uncontrolled. Refer to Ashghal's website for the most recent version.

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Rev	**Date**	**Reason For Issue**	**Auth**	**Chk**	**App**

Contents

1. Foreword

1.1 Interim Advice Notes (IAN) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Design Department, Infrastructure Affairs.

Signed on behalf of Design Department:

Abdulla Ahin A A Mohd
Acting Manager of Roads & Drainage Networks Design
Design Management (Roads Section)
Public Works Authority
Tel: 44950653
Fax: 44950666
P.O.Box 22188 Doha - Qatar
Email:aahin@ashghal.gov.qa
http://www.ashghal.gov.qa
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2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
Organisation:		Email:	
Position:		Address:	

Please email the completed form to:

Abdulla Ahin AA Mohd

Acting Manager of Roads and Drainage Networks Design
Design Management
(Roads Section)
Public Works Authority

aahin@ashghal.gov.qa

We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3. Introduction

3.1 This Interim Advice Note (IAN), which takes immediate effect, provides the Specification to be used for bridge bearings. This IAN will provide interim guidance prior to issue of a revision to the Qatar Construction Specifications (QCS).

3.2 The specification is applicable to all bridges with bridge bearings.

4. Additional Standard

4.1 For application to bridge structures and to be added to the next revision of the Qatar Construction Specifications (QCS).

5. Implementation

5.1 This IAN is to be used with immediate effect on projects as follows:

- All Ashghal projects in Design Stage
- All Ashghal projects in Tender Stage

5.2 Ashghal projects in Construction Stage shall be reviewed by the Project Consultant / Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager.

5.3 The only exceptions are:-

- Projects already in Construction, where a significant proportion of bearings have been procured, where this would result in a significant additional cost or delay.

5.4 If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

Appendix A – QATAR CONSTRUCTION SPECIFICATIONS (QCS) 2010 Additional Section 101, Part 3, Bridge Bearings

Appendix A List of Contents

3 BRIDGE BEARINGS

3.1 GENERAL

3.1.1 Work Included

1. Furnish all labour, materials and equipment required for the design, manufacture, supply and installation of bearings shown on the Drawings and/or in the Specifications and includes the following:

2. Moulded Reinforced Elastomeric Bearings.

   Reinforced elastomeric bearings consist of alternate layers of elastomer (Neoprene or natural rubber) vulcanized and bonded to embedded layers of reinforcement. The reinforcement, which consists of either thin steel plates or fabric laminates, is added to restrain the lateral bulging of the elastomer when sustaining large loads. These bearings accommodate both translation and rotational movements through the deformation of the elastomer.

3. Disc-Type Bearings.

   Disk bearings consist of a polyether urethane structural element (disk) confined by upper and lower steel bearing plates. A shear resisting mechanism (steel pin) located through the center of the disk is utilized to transfer all lateral loads applied to the bearing and to prevent lateral movement of the disk. It is a low-profile alternative bearing and similar to the spherical bearing it can be designed to accommodate large cyclical live load rotations.

4. Pot-Type Bearings.

   Pot bearings have a cylindrical elastomeric pad confined within a pot, the latter having a piston cover that transfers the load to the pad. The elastomer is deformed at constant volume only, which means that it can withstand considerable loads as well as the rotations of the structure.

5. Spherical-Type Bearings.

   Spherical bearings consist of a spherical rotational component, where typically a stainless steel convex surface (alternatively made of highly corrosion resistant sliding alloy) slides against a concave carbon steel plate covered with a low friction sliding material. This is a compact bearing able to accommodate larger rotations and vertical loads as it does not depend on the limitations of an elastomeric element.

6. Moulded Elastomeric Bearing Strips.

   The elastomeric bearing strip consists of a strip of solid section of elastomer (Neoprene or natural rubber) installed on the corbel at the back of the abutment backwall to support the approach slab. It is designed to accommodate the rotational movement of the approach slab. Stainless steel dowels passing through the bearing prevent longitudinal movements of the approach slab.

3.1.2 Related Work

1. Examine work done by other trades: Before commencing fabrication of the work of this Section, the Contractor installing the bearings is required to inspect and take field measurements of work done by other trades which may affect the work. Before commencement of the work, the Contractor shall notify the engineer in writing, of his acceptance of work done under other Divisions or by other trades. If any conditions exist which will prejudice a proper installation of the work, the engineer shall be notified in writing, and installation shall not proceed until deficiencies are corrected and the engineer has received the letter of acceptance.
2. Cooperation: Where items of other trades are to be built into the work of this Section or items under this Section are to be built into the work of other trades, such items shall be procured and provided in ample time to avoid delay.
3. The Contractor shall attend upon and cooperate with other trades in respect of the work of this Section and do everything necessary to enable the work of other trades to be completed without delay.

3.1.3 Approvals

1. Prior to manufacturing the bearings and prior to the construction of the bearing seats, the Contractor shall submit the following information to the engineer for consideration and approval:
2. The Bearing Manufacturer's specification containing detailed information on the design standards, materials, manufacture and technical data.
3. The Contractor shall submit a Technical Approval document which will guarantee the service life of the bearings to be not less than 50 years
4. Shop drawings detailing all of the work of this section.
5. Friction properties based on actual tests at a temperature of 70°C conducted on relevant materials and all other tests completed in accordance with the specifications.
6. Design calculations clearly indicating how the bearing, including attachments, anchorages, etc., satisfies the design criteria indicated on the Drawings and in the specifications
7. Detailed procedures/method statement to be followed during the installation, replacement and inspection of bearings
8. A certificate of compliance from the Bearing Manufacturer of the work to be done under this section
9. The Contractor shall submit evidence of the successful installation and operation of comparable proprietary bearings to the satisfaction of the Engineer. These should demonstrate the suitability of the system and materials proposed, in particular, for heavy traffic and for the aggressive environment and high temperatures experienced in the Middle East.
10. The approval of the Engineer shall not relieve the Contractor of any responsibility under the Contract for the successful completion of the work.
11. The bearing manufacturer shall facilitate one or more visits by the engineer or his representative to his workshop for the purpose of quality control.

12. The Engineer may at his discretion select an entire bearing, forming part of the batch belonging to this contract, for testing in order to ascertain the bearings compliance with the certificates supplied by the manufacturer. In such case the contractor shall provide a new bearing at the scheduled rates tendered for this contract to replace the bearing being tested.

3.1.4 Shop Drawings

1. The Contractor shall submit shop drawings to the engineer for approval which shall include, but not limited to, the following information.
2. Erection drawings, plan, elevations and complete details and sections showing all materials incorporated in the bearings.
3. Design calculations for the bearings and the anchorages which will prove compliance with the standards.
4. Bearing preset details, if applicable.
5. Protective coating requirements.
6. The attachment details of the sliding material (PTFE, SSM, etc.) to the steel substrate (guide bar, piston, top plate, etc.).
7. Attachment details of the stainless steel plates to the bearing elements.
8. The maximum and minimum vertical loads and co-existing horizontal loads as well as the maximum horizontal load and co-existing vertical load including a bearing schedule according to EN 1337-1.
9. Bearing seat and all bearing connection and anchorage details.
10. The location of the top and bottom bearing adapter plates drawn in plan and in elevation on the deck soffit and on the support structures showing edge distances.
11. The bearing orientation (uni and multidirectional bearings) with respect to the point of zero temperature movement of the bridge deck or to other points of reference as indicated on the drawings.
12. A summarized list of all bearings to be installed providing the bearing identification mark, type, corresponding design loads and preset
13. The drawings and design calculations shall be stamped by a professional engineer employed by the bearing supplier with at least 5 years of documented history of bearing design experience.

3.2 STANDARDS

1. Unless otherwise specified, the design and the manufacture of the bearings shall comply with the following requirements:

Mandatory Standard	
Highways Agency (UK) Design Manual for Roads and Bridges (Volumes 1 & 2 (DMRB)	
EN 1337-1	General Design Rules
EN 1337-2	Sliding Elements
EN 1337-3	Elastomeric Bearings
EN 1337-5	POT Bearings
EN 1337-7	Spherical and Cylindrical Bearings
EN 1337-8	Guide Bearings or Restraint Bearings
EN 1337-9	Corrosion Protection
EN 1337-10	Inspection and Maintenance
EN 1337-11	Transport, Storage and Installation

Advisory Standard
BS 5400-9-1:1983 and BS 5400-9-2:1983 as implemented by the DMRB
AASHTO LRFD Bridge Design Specifications
AASHTO LRFD Bridge Construction Specifications
AASHTO LRFD Standard Specifications for Highway Bridges
Steel Bridge Bearing Selection and Design Guide, Volume II, Chapter 4, Highway Structures Design Handbook
SCEF Standard 106
AASHTO/NSBA Steel Bridge Collaboration G9.1 – 2004
NCHRP Report 10-20A, High load Multi-Rotational Bridge Bearings, Transport Research Board, National Research Council, Washington D.C., 1993

Permissible Standard
Other approved standards which should be used in special cases to accommodate design constraints and to be compatible with the local conditions

2. All the above and any other documents and specifications referred to in this document shall be the latest edition or superseding document and specification

3.3 MATERIALS

3.3.1 General

1. Each batch of material (steel, sliding elements, stainless steel plates, lubrication, etc.,) need the approval from an approved, independent testing authority (Material Testing and Controlling Institution, BBA or MPA Stuttgart or similar approved), before assembly of the parts. The bearings shall be fabricated from only new and unused materials. Reclaimed materials are not acceptable.
2. When requested by the engineer, the contractor shall submit test certificates from the approved, independent testing authority to show that the respective materials comply with the specified requirements, or a certificate from the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.
3. In addition to the requirements of the above stated mandatory standards (see S4.6.2) materials shall conform to the following standards:

3.3.2 Structural Steel

1. Steel substrates to which the sliding material is bonded shall be grit blasted prior to applying the epoxy adhesive. Bond over the entire area of the sliding material.
2. Metal to metal contact surfaces within bearings (inclusive of the top and bottom adapter plates) shall be prepared either by machining or fine grinding. Machining shall always be carried out after welding has been finished.
3. The type and country of origin of the structural steel utilized in the manufacture of the bearings shall be subject to the Engineers approval
4. The steel grade shall be S355 and S235 to EN 10025 or steel with equivalent elongation at break

3.3.3 Highly Corrosion Resistant Sliding Alloy used for the Manufacture of the Convex Element of Spherical Bearings

1. The material MSA manufactured in accordance with the European Technical Approval ETA-06/0131 is approved. Alternative equivalent materials will be subject to the engineer's approval.
2. The corrosion resistant material shall be approved in the form of a "Technical Approval" released by the European Organisation for Technical Approvals – EOTA.
3. The following properties shall be at least equal to that of stainless steel for the proper functioning of the bearing during its design life:
   (i) Hardness of surface
   (ii) Durability of surface. Resistant to wear during life of bridge.
   (iii) Frictional resistance with the sliding material
   (iv) Bright annealed mirror (No. 8) finish (less than 0.2 µm RMS) for the surface in contact with the sliding material
   (v) Capacity to resist vertical loads during bearing rotation

3.3.4 Stainless Steel Sheet

1. Shall conform to EN 10088-4 grade EN 1.4401 or EN 1.4404 steel and be continuously welded to the steel plate. Locate the weld outside the contact area with the sliding material surface.
2. Face of the stainless steel in contact with the sliding material: bright annealed mirror (No. 8) finish (less than 0.2 µm RMS). Finishes on curved metallic surfaces shall not exceed 0.4 µm RMS

3.3.5 Anchor Bolt Assemblies

1. All anchor bolt assemblies, inclusive of anchor sockets/dowels, anchor bolts and washers shall be of Grade 8.8 steel. The anchor bolts and washers shall be hot-dip galvanised to EN ISO 10684. Should higher grades of steel be required to suit the applied loads, attention is drawn to the need to consider the risk of hydrogen embrittlement when selecting an appropriate surface treatment process, which shall be subject to the approval of the engineer.
2. The anchor sockets/dowels shall be welded to the top and bottom adapter plates with holes machined into the welded end of the dowels and adapter plates to receive the anchor bolts. The anchor sockets/dowels shall receive the same corrosion protection as that of the adapter plates.
3. The threaded portion of the sockets/dowels shall be applied with an approved lubricant/grease prior to the insertion of the bolts for protection against corrosion
4. A durable, ultra violet resistant and tight fitting plastic cap shall be installed on top of all anchor bolt heads for further protection against corrosion. The bolt caps shall be free of defects which will impact its intended purpose of providing further protection against corrosion, such as cracks, for a warrantee period of five years from time of installation. During the warrantee period all defective caps shall be replaced at no cost to the Ow

3.3.6 Sliding Materials

3.3.6.1 Special Sliding Material (SSM) with Low friction

1. An alternative special sliding material made of modified UHMWPE - Ultra high molecular weight polyethylene is approved subject to the following requirements
2. The use of the SSM material as a sliding surface shall be shown to be in compliance with the necessary European Technical Approval (ETA) certificates according the CUAP 03.01/35.
3. The materials performance in service as a “low friction” material shall be confirmed by a long term test using an independent testing institute (Material Testing and Controlling Institution, BBA or MPA Stuttgart, or similar approved) with the following conditions:
   (i) Average test contact pressure 60N/mm²
   (ii) Constant test sliding velocity 15mm/s
   (iii) Test sliding path 50km

4. Sliding material with low friction behaviour (μ < 2,0% with temperature range of -50 to + 70 °C).

5. Maximum sliding coefficient during –35°C test shall not exceed μ < 3,5% over the long term testing distance.

6. Because of the hot ambient temperatures, the characteristic permissible pressure of the sliding material shall not less than:

   (i) with room temperature (20°C) fk = 180N/mm²
   (ii) with 70°C fk = 90N/mm²

7. Creep behaviour with both values shall be confirmed by testing at an independent testing institute (Material Testing and Controlling Institution, BBA or MPA Stuttgart, or similar approved).

8. A permissible combination of materials of the tribological systems (main sliding surfaces) adjacent to the convex plate (spherical part) of a spherical bearing shall consist of SSM (See S4.6.3.5.1) with stored silicone grease against

   (i) Austenitic steel for the flat sliding surface and
   (ii) Highly corrosion resistant sliding alloy MSA for the curved sliding surface

9. Other combinations of materials proposed by suppliers which introduce new untested and unapproved materials apart from the use of stainless steel and PTFE and other permissible combinations of materials approved for use by EN 1337-2 will be submitted to the Engineer for approval prior to use.

3.3.7 Adhesive Material

1. The adhesive material used for bonding the sliding material onto the steel substrate shall be an epoxy resin satisfying the requirements of ASTM C 881/C 881M, FEP film or equal, as approved by the engineer.

2. It shall be stable from -40ºC to 125ºC.

3. Care shall be taken to ensure that the adhesive is applied uniformly over the entire surface of the sliding material so as not to cause an uneven sliding surface that could lead to premature wear.

3.3.8 Elastomeric Material for Pot Bearings

1. The raw elastomer shall be either Neoprene (polychloroprene) or virgin natural rubber (polyisoprene) moulded in one piece. No layering or stacking of discs will be permitted. Cuts, gouges or nicks from machine cutting or flash trimming will be cause for rejection.

2. The sealing groove shall be moulded integrally. It shall be square to the pad top surface and the same nominal dimensions as the brass sealing rings.

3. A silicone grease shall be used as the lubricant to be applied to the top and bottom surfaces of the elastomer to prevent its abrasion during cyclic rotation

4. The physical and mechanical properties of the elastomer shall comply with the requirements of EN 1337-3.

3.3.9 Brass Sealing Rings:

1. Three rectangular brass sealing rings shall be provided to prevent the elastomer extruding between the piston and pot wall.
2. The rings shall be finished to a smoothness of 1.6 µm RMS or better.
3. Each ring shall be circular in plan but shall be cut at one point around its circumference. The faces of the cut shall be on a plane at 45º to the vertical and to the tangent of the circumference with a gap of 1 mm. The gaps shall be staggered a minimum of 90º relative to one another when the rings are in place.
4. The width of each ring shall not be less than either 0.02 Internal Diameter of the Pot or 6 mm and shall not exceed 20 mm. The depth of the ring shall not be less than 0.2 times its width.
5. The Engineer may approve other sealing systems as proposed in EN 1337-5 if the bearing manufacturer produces documental and experimental evidence proving its successful use in practice.

3.3.10 External Seals for Pot and Spherical Bearings

1. The bearings shall be provided with tight-fitting seals to prevent the ingress of dust or deleterious matter onto the moving parts. The seals shall be of an approved type and sufficiently durable to last in excess of 50 years

3.3.11 Moulded Reinforced Elastomeric Bearings

1. The elastomeric bearings shall be designed and manufactured to EN 1337-3 with the following additional requirements:
2. The internal steel reinforcement layers shall be deburred or otherwise rounded prior to moulding the bearing.
3. The minimum nominal thickness of internal steel plates used to reinforce elastomer components shall be 3 mm. The embedded steel shall have a minimum elastomer cover of 6mm
4. Tapered elastomer layers shall not be used. All internal layers of elastomer shall be of the same thickness. The top and bottom cover layers of elastomer shall be no thicker than 70% of the internal layers.
5. Holes are strongly discouraged in moulded reinforced elastomeric bearings.
6. Type A, B, D and E elastomeric bearings shall be positively located on their plinths by guide bars welded to the base (masonry) steel plate on all four sides of the bearings in addition to epoxy or vulcanized bonding of the bearing to the masonry plate. The masonry plate assembly inclusive of its anchor studs shall be galvanised to EN ISO 10684.

3.3.12 Disk Bearing Rotation Element

1. The elastomeric rotational element (disc) shall be moulded as a single piece, separate layers are not allowed.

2. The rotation element shall be moulded from a polyether urethane polymer compound with the following physical properties:

Physical Properties		ASTM Test Method	Requirements	
			Min.	Max.
Hardness Type D Durometer		D2240	60	65
Tensile Stress MPa	@ 100% Elongation	D412	14	-
	@ 300% Elongation	D412	26	-
Tensile Stress MPa		D412	34.5	-
Ultimate Elongation %		D412	220	-
Compression Set 22 hrs @ 70°C %		D395	-	40

3. The elastomer shall remain flexible at temperatures at or above -70°C.

4. The elastomer portion of the elastomeric compound shall be 100% polyether urethane with no reclaim or ground polymers reinforcement allowed.

5. Rotation of the disc bearings about a horizontal axis is to be limited such that vertical strain induced at the perimeter of the rotation element under combined vertical, rotational and eccentric loads including creep effects does not exceed 0.15. Design calculations supported by test results to be submitted for review.

6. Caution shall be taken to ensure that the steel temperature directly adjacent to the polyether urethane rotational element dos not exceed 107ºC. The polyether urethane disk must not be exposed to direct flame or sparks.

3.4 DESIGN REQUIREMENTS

3.4.1 General

3.4.1.1 Serviceability Limit State

1. The design should be such that bearings will not suffer damage which would affect their correct functioning or incur excessive maintenance costs during their intended life.
2. For all load combinations, the horizontal to vertical load ratios shall not be greater than 40%. In such cases allowance for external restraint shall be provided unless otherwise approved by the engineer.
3. The minimum vertical load on any bearing shall not be less than 20% of the maximum vertical design load at the serviceability limit state.

3.4.1.2 Ultimate Limit State

1. The strength and stability of bearings should be adequate to withstand the ultimate design loads (concurrent vertical and horizontal loads) and movement of the structure.

3.4.1.3 Design Life

1. Bearings and their installations should be designed to be compatible with the design life of the bridge; taking into account the consequences of maintenance and/or replacement.

3.4.1.4 Durability

1. Bearings should be detailed to exclude crevices and the like which allow moisture and dirt to be trapped. The materials used in their manufacture and the protective and maintenance measures adopted against corrosion and deterioration due to environmental effects should be such as to ensure that bearings continue to function correctly throughout their design life.
2. The bearing manufacturer shall ensure that bearing elements that are subject to deterioration and require future maintenance, such as the sliding materials, are detailed such that ease of access for inspection and replacement is taken into account in his design.

3.4.1.5 Replacement of bearings

1. The substructure and superstructure design shall permit the bearings to be removed for inspection or rehabilitation with minimal jacking of the structure. The design of bearings shall be accompanied by a detailed method statement for their replacement.
2. Sufficient space shall be made available on top of bridge supports (at abutments and piers) and on the soffit of bridge superstructures within the width of deck diaphragms to enable the location of jacks during bearing replacement.
3. Bearings shall be designed so that they can be replaced by lifting the deck no more than 10 mm or the distance specified.

4. The replacement parts shall be at least equal to the original quality of the parts replaced.

3.4.1.6 Top (sole) and bottom (masonry) adapter plates

1. Top and bottom adapter plates shall be provided to allow for simple bearing replacement.
2. The fixing arrangement of the bearing to the top and bottom adapter plates shall be such as to enable the bearings to be replaced without the need for cutting into the bridge superstructure or substructure. The bearing may be attached to the masonry plate by seating it in a machined recess and bolting it down. To replace the bearing the bridge will need to be lifted a height equal to the depth of the recess.
3. The adapter plates shall be designed to distribute the bearing loads into the surrounding substructure and/or superstructure and shall be sufficiently stiff to remain rigid under all service load conditions. The design verification rules applicable to backing plates in EN 1337-2 shall also apply to the design of the adapter plates. The thickness shall not be less than 20mm. The surfaces of the adapter plates in contact with the bearing elements shall be prepared by either machining or fine grinding to ensure full contact of surfaces during loading and shall have an evenness of at least 0.0003 x length of the diagonal of the attached bearing element. Machining shall always be carried out after welding has been finished.

3.4.1.7 Average Bearing Stress on Concrete

1. The outer plates of bearings should be so proportioned that concentrated loads are sufficiently distributed to ensure that the permissible stresses on the adjacent bridge structure are not exceeded.

3.4.1.8 Rotation of the bearings

1. The rotational capacity of all types of bearings about any horizontal axis, which includes rotations due to all applicable service loads and movements, maximum rotations caused by fabrication and installation tolerances, and allowance for uncertainty, should be at least ± 0.02 radians.
2. Rotation of Pot and Disk bearings about a horizontal axis shall be limited such that vertical strain induced at the perimeter of the rotation element (elastomer or disk) under combined vertical, rotational and eccentric loads including creep does not exceed 15% of the nominal rotation element thickness. Design calculations, supported by test results, if required by the Consultant, to be submitted for review.
3. Vertical and horizontal clearance between the rotating and non-rotating bearing components, including fasteners, shall be no less than 5mm when rotated to 150% of the design rotation

3.4.1.9 Protective Dust Covers

1. Dust covers shall be provided on the circumference of the bearings. They shall provide sufficient protection such that dust or debris does not penetrate through to the bearing sliding surfaces and elements. Details of the dust covers shall be submitted to the

engineer for his approval prior to manufacture. They shall be robust, made up of ultraviolet resistant material, allow for ease of inspection and be replaceable. The bearing manufacturer shall warrantee their performance for a period of at least 15 years.

2. This detail will not be required if aluminium dust covers have been specified on the circumference of the pier column tops, abutments and wherever bearings are located. In such cases they shall be demountable for the purpose of their manual removal and reinstatement for the inspection of bearings using simple hand tools without the need for heavy equipment.

3.4.2 Sliding Materials

3.4.2.1 General

1. The designer shall account for the high effective bearings temperatures existing in Qatar in his design of the sliding materials, particularly the effects of high temperatures on the characteristic compressive strength and stiffness of the sliding materials. The bearing manufacturer shall provide experimental evidence of the performance of proposed sliding materials for temperatures in the range of 30ºC to 70ºC.

2. The coefficient of friction shall be established using friction tests in accordance with EN 1337-2 for lubricated and unlubricated sliding materials. The results of the tests carried out on unlubricated sliding materials shall be obtained for information only. If an approved alternative sliding material is proposed, an ETA shall be submitted to describe the friction properties and the combination of sliding materials.

3. Bearing manufacturers shall also provide to the engineer the expected maximum coefficient of friction for bearings which have undergone extensive wear during the life of the structure.

3.4.2.2 Methods of attachment

1. Horizontally installed sliding material shall be recessed and preferably bonded into its steel substrate. The Contractor shall guarantee the performance in service of the sliding material during the warrantee period of the bearing. He shall take into consideration possible “out of alignment” errors during installation on site between the base and upper elements of the bearing. Unless proven otherwise bonding is recommended whenever there are difficulties in creating, readjusting or retaining the parallelism of the contact surfaces between the base and upper elements of the bearings.

2. The connection of the sliding material to the steel substrate shall be subject to the approval of the engineer.

3. Vertically installed sliding material sheet shall be bonded and recessed into or bonded to and mechanically fastened to its steel substrate

4. The recess into the steel substrate shall be designed in accordance to the technical approval of the bearing for the sliding material sheet thickness. The ratio between the recessed part of the sliding material and the emerging protrusion shall be at least 1.2. The shoulders of the recesses shall be sharp and square and the radius of the root of the recess shall not exceed 1 mm.

3.4.2.3 PTFE Sheets

1. For all application the thickness of the PTFE shall always be greater or equal to 5 mm and smaller or equal to 8 mm.
2. After completion of the bonding operation the PTFE surfaces shall be smooth and free of blisters and bubbles.
3. In the absence of test data, the coefficient of friction for pure unlubricated PTFE on stainless steel should be taken as twice the values for lubricated PTFE.
4. Wear may ultimately cause the need for replacement of the PTFE, so it is wise to allow for future replacement of the PTFE in the original design.

3.4.2.4 SSM Sheets:

1. It shall be designed strictly in accordance with the material manufacture's specifications and recommendations. Limiting stresses on the material shall be in accordance with the material manufacture's specifications.
2. SSM or any other PTFE replacement materials proposed by the bearing supplier shall be demonstrated by tests from approved internationally recognized laboratories to perform at least equal to or better than PTFE in all aspects of bearing design requirements.
3. The performance of the replacement materials shall be demonstrated with the use of lubricants such as silicone grease and in the absence of lubricants. Actual friction values shall be considered for the design of bridge elements.

3.4.3 Guides

1. Guides are used to prevent movement in one direction such as in uni-directional bearings.
2. Guides shall be fabricated integral with the bearing base element when they are centrally located at the top of the piston in pot bearings and at the top of the convex spherical element in spherical bearings. In such cases bolted down or welded guides shall not be permitted.
3. Guides which are located along the outer edges of the bearing may be welded to the bearing top sliding plate as indicated in Figure 8 of EN 1337-2. When the bottom or base plate are used as the restraining device for the guides, the bearings have limited rotational capabilities and may restrict the free rotation of the bridge at the support where the axis of rotation of the bridge is parallel to the longitudinal axis of the guides. In such cases special adaptations to the guides (such as by the addition of rockers or tilting bars) will need to be considered to accommodate the rotations of the bridge. Such details shall be subject to the approval of the engineer prior to manufacture.
4. The following rules shall apply:
   (i) Under no circumstance shall there be separation between the bearing top plate supporting the guide and the top adapter plate when the guide is subjected to 150% of the design horizontal force applied to the bearing

(ii) The longitudinal dimension of the top plate shall be determined by considering full movement range of deck superstructure and possible movement of the substructure accounting also for the tolerances in EN 1337-1 cl. 5.4

(iii) Machining of the inside face of the top plate and guides and that of the top surface of the top plate shall be done after welding is completed

5. The guides shall be self-aligning to ensure complete contact of the sliding material and the stainless steel surfaces along the entire length of the guide providing the lateral restraint.

6. The closing of the gap on one side of the guide and locking of the bearing in that position during transportation and installation may not be utilized to ensure complete contact of the sliding material and the stainless steel in service.

7. Guides used for lateral restraint shall be faced with a low-friction sliding material to ensure that the frictional resistance to movement due to the guides is significantly smaller than that of the main bearing. The sliding material:

(i) Shall be attached to the guide by either of the following methods:

(a) Bonding and recessing in accordance with the technical approval document. The recess shall be at least one half of the sliding material thickness. The attachment of steel plates to the guides to form the recess shall not be permitted.

(b) Bonding and mechanical attachment with fasteners, which shall be countersunk to a depth which ensures that they will not touch the mating material after allowing for wear.

(ii) Shall be etched prior to bonding by the method approved by the Manufacturer.

Alternative sliding materials to that approved for use by EN 1337-2 may be permitted provided that it can be demonstrated to the Engineer that such materials are fully compatible with all other requirements of this specification. The material SSM referred to in this document is permitted for use as guides

8. The total gap between guides and guided members shall not exceed 2 mm. However it should be noted that free slip causes the load to be distributed unevenly which could potentially lead to overloading of one guide/bearing and this needs to be taken into account in the design.

3.4.4 Multidirectional Bearings

1. Bearings which are not required to provide restraint, shall be attached to the structure by anchor bolts or other approved methods. The friction between the bearing and the superstructure and substructure shall not be considered to assist in resisting horizontal forces

3.4.5 Anchor Bolt Assemblies:

1. The anchor sockets/dowels welded to the underside of the bottom adapter plates shall be at least 30mm in diameter. They shall be corrosion protected together with the bottom adapter plate. The insides of the anchor bolt holes machined into the top of dowels may be left unpainted as these holes shall become sealed after tightening of the anchor bolts.
2. The dowels set in the bearing plinths shall extend beyond the top mat of reinforcement in the abutment and/or pier
3. The dowels shall be located in their sockets using an approved high strength shrinkage compensated cementitious grout applied strictly in accordance with the material manufacturer's recommendations and specifications. The grout shall be subject to the approval of the engineer
4. The anchor bolts shall be limited in length by the need to remove the anchor bolts during future bearing replacement. There shall be no obstruction which will impede the unfastening of the anchor bolts during bearing replacement
5. If bearings are not recessed into the adapter plates, the anchor bolts shall be designed to resist the full horizontal design loads from the bridge superstructure without any reliance on the frictional forces developed from steel to steel contact between the bearing elements and the adapter plates

3.4.6 Stainless Steel Sheet

1. Stainless steel sheets shall be attached to their backing plates with an approved epoxy to ensure complete contact and then by continuous welding along their edges so as to prevent ingress of moisture and shall be clean, sound, smooth, uniform; without overlaps and ensure that the stainless steel sheet remains flat throughout its service life.
2. Bonding and/or mechanical fastening of sheets without welding along edges will not be permitted.
3. The attachment of the stainless steel to the steel substrates shall be able to withstand a minimum of 20% of the maximum applied bearing load in the shear plane.
4. The backing plates shall extend beyond the edge of the stainless steel sheets to accommodate the welds and the welds shall not protrude above the stainless steel sheets.
5. The stainless steel sheets shall completely cover the PTFE sheets in all operating positions, plus at least 25 mm in the direction of movement.

3.4.7 Welding

1. Welding shall be in accordance with the EN ISO welding norm EN ISO 3834 and EN 1090.

3.4.8 Specific design requirements for each type of bearing

3.4.8.1 Pot Bearings

1. The pot, piston, top sliding plate and base plate shall be fabricated by machining a solid steel casting. No welding or bolting or riveting of parts will be permitted.
2. The inside diameter of the pot cavity shall be nominally equal to the diameter of the elastomeric pad.
3. The pot shall be deep enough to permit the seal and piston rim to remain in full contact with the vertical face of the pot wall under all design loads, movements, and rotations.
4. Contact between metal components shall not prevent further displacements or rotation.
5. The pot walls shall be designed to withstand both the internal pressures caused by vertical loads (considering the elastomer to behave as a fluid) and the design lateral loads.
6. The finish of surfaces in contact with the elastomeric pad shall be smoother than 1.5μ-m.
7. The yield strength and hardness of the piston shall not exceed that of the pot.
8. The combined thickness of the bottom adapter plate and the base plate of the pot shall not be less than 6% the inside diameter of the pot. Each of these plates shall individually not be less than 20mm in thickness.
9. When at 150% of maximum design rotation, the piston thickness shall be sufficient to provide at least 5 mm vertical clearance between rotating and non-rotating components of the bearing assembly.
10. The thickness of the piston shall not be less than 6% the inside diameter of the pot, except at the rim.

3.4.8.2 Spherical Bearings

1. The concave and convex spherical element will be machined from a solid block of structural and non-corrosive steel respectively.
2. The minimum center thickness of the concave spherical element and the minimum edge thickness of the convex spherical element shall be at least 20 mm.
3. Unseating of the curved spherical surfaces relative to each other shall be prevented by transferring horizontal forces through specifically designed restraints or by control of the spherical radius.
4. If rockers or tilting bars are utilized to allow transversal rotation in uni-directional bearings with outer side guides they shall be made of stainless steel conforming to EN 10088. Also metal to metal contact at the base of the rockers or tilting bars shall be between two stainless steel materials to prevent the onset of corrosion in these areas. Locating pins utilized to prevent the rockers from sliding out from between the side guides and bearing main element shall also be of stainless steel conforming to EN 10088.

3.4.8.3 Disk Bearings

1. The elastomeric disc shall be held in location by a positive locator device
2. At the serviceability limit state the disc shall be designed so that:
   (i) The deflection under total load ≤ 10% of the thickness of the disc
   (ii) The additional deflection due to creep ≤ 8% of the thickness of the disc
   (iii) The average compressive stress on the disc ≤ 35 MPa calculated on the smallest plan area of the disc if disc edges are not vertical
3. For large cyclical live load rotations applications:
   (i) The vertical load support element (elastomeric disc) shall be designed for rotational fatigue at the design vertical load. Rotational loading shall be static dead load rotation plus cyclic live load rotation. Unless otherwise specified, the minimum number of cyclic design rotations shall be 5 million.
   (ii) In lieu of long term testing, accelerated rotational fatigue, life testing may be performed with 15,000 complete cycles at ± 0.02 radians on a minimum of three full size bearings.
   (iii) Rotational fatigue test results shall be provided to the engineer for approval.
4. Shear Restricting Mechanism:
   (i) The shear restricting mechanism (pin) shall allow the bearing device to rotate but prevent shear from being applied to the elastomeric disc.
   (ii) The pin shall be fabricated integral with the bearing base elements. Welding of the pin to the bearing base element shall not be permitted.
   (iii) At maximum rotation the shear restricting mechanism shall be capable of resisting the maximum horizontal force in any direction equal to the larger of
   (iv) The design shear force at ULS
   (v) 15% of the design vertical load at SLS
   (vi) The finished shear restricting mechanism shall have a smooth finish of 3.2 µm RMS or better.
   (vii) The shear restricting mechanism shall be fully functional at 2 times design rotation.
   (viii) Under conditions of maximum load, deflection (including creep where appropriate) and 150% rotation, the minimum clearance between opposing steel parts shall be not less than 0.02 x (times) diameter of the disc.

3.5 EXECUTION

3.5.1 Dimensional Tolerances

1. The manufacturing, assembly and tolerances shall be in accordance with the following parts of EN 1337:
   (i) Sliding elements – Clause 7 of Part 2
   (ii) Elastomeric bearings – Clause 6 and 7 of Part 3
   (iii) Pot bearings – Clause 7 of Part 5
   (iv) Spherical bearings – Clause 7 of Part 7
   (v) Disk bearings – tolerances for pot and spherical bearings shall also apply for disc bearings
2. When designed to be parallel, the tolerance of parallelism of any upper surface of a bearing with respect to any lower surface of the bearing, as datum, shall be 0.2% of the diameter for surfaces circular in plan and 0.2% of the longer side for surfaces rectangular in plan.

3.5.2 Corrosion protection of bearings

1. All exposed steel parts of bearings not made from stainless steel shall be protected against corrosion by the following approved paint system:
   (i) The protective coating shall be a HIGH MARINE COATING CORROSION PROTECTION SYSTEM. Atmospheric corrosively category C5-M. Expected durability high (H – more than 15 years) according to ISO 12944-5:1998(E)
   (ii) Prepare the surfaces by abrasive blasting to a finish equal to the Sa1/2 finish of Swedish Standard SIS 05 59 00.
   (iii) Spray the surfaces with zinc dust EP primer with a minimum 80 micrometer thickness (Zinc Flame Spray).
   (iv) Coat the zinc-sprayed surfaces within 4 hours with two layers (1st and 2nd) of MIO (micraceous iron oxide) each with minimum thicknesses of 80 µm (two coats), with the exception of the stainless-steel siding plate
   (v) Apply a final coat (top layer) of MIO (micraceous iron oxide) minimum 80 µm in thickness (third and final coat)
   (vi) The total thickness of the protective coating system shall not be less than 320 µm.
   (vii) A transition zone of at least 50mm in width on the circumference of the top and bottom adapted plates in contact with concrete shall receive the same paint system
2. All surfaces of steel parts in contact with concrete and other steel mating surfaces shall be protected against corrosion by zinc metallization.
3. Corrosion protection systems shall not be applied to the internal surfaces of pot nor to the surfaces of the piston in contact with the pot and elastomer for pot bearings.
4. The bearing manufacturer shall guarantee the long term protection against corrosion of any unpainted surfaces of bearings and other unpainted surfaces of steel such as the inside of bolt holes, etc.

3.5.3 Identification

1. All bearings must be clearly coded by the manufacturer. The coding must prevent mix-up and remain clearly visible on the bearings.
2. Each bearing shall be stamped with the manufacturer's name, bearing type or model number, bearing number, direction of installation and the installed location which must correspond with the information contained on the approved drawings for the bearings. The stamp shall be on a surface visible after installation.
3. The direction of required displacement of bearings shall be clearly marked with a large and bold arrow on the top side of the bearings. The bearing centre lines required to locate the bearings in plan at bridge supports shall also be clearly shown on the top side of the bearing.

3.5.4 Handling, Transport and Storage

1. Protect bearings from damage or distortion during handling, transport, storage and installation and keep clean and free of all deleterious matter and contaminants including moisture and dust.
2. Provide suitable handling devices as required. Use temporary clamping devices to maintain correct orientation of the parts during handling, transport, storage and installation but do not use for slinging or suspending bearings unless specifically designed for this purpose.
3. All bearings, whether in the fabrication shop or an independent warehouse or at the bridge site shall be stored on a platform above ground surface, in a clean, dry, covered facility, away from sunlight, heat, oils and chemicals deleterious to the bearings.
4. The bearings shall not be staked in a manner or on a surface which will cause distortion of the bearings.
5. When in storage the bearings will be kept banded, wrapped and secured in a condition suitable for shipment.

3.5.5 Installation of bearings in general

1. Install bearings in the structure as specified and shown on the drawings and directed by the bearing supplier. Installation procedure shall be subject to review and approval by the engineer. The manufacturer will have its technical representative present for the placement of the first elastomeric bearing, Uni-directional, Multi-directional and Fixed mechanical bearing.
2. Bearings shall be set to the dimensions and offsets prescribed by the manufacturer and the drawings. When placed, bearings shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.
3. They shall be adjusted as necessary to take into account the temperature at time of installation and future movements of the bridge due to temperature changes, release of falsework and shortening due to prestressing.

4. However, adjustments, inclusive of any modifications required to the bearing pre-set, which require the dismantling of any parts of the bearing or its temporary attachments or clamping devices shall be carried out in the factory prior to shipping.

5. Under no circumstances shall bearings be taken apart and reassembled on the site, except where it is an unavoidable feature of the installation procedure, in which case the dismantling, installation and reassembly shall be subject to the approval of the bearing manufacturer or his agent and carried out under his supervision.

6. At the option of the manufacturer or the design engineer, the technical representative may be required to be present for the placement of any number of additional bearings.

7. Rehabilitation, modification and repair work to the bearings shall be carried out only in the factory or in an approved engineering works.

8. Agree to the position of any temporary packing between the outer bearing plates and the structure with the Consultant.

9. Locate bearings so that their centre lines are within ± 3 mm of their correct positions.

10. Level of a single bearing or the mean levels of more than one bearing at any support shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ± 5 mm.

11. Set bearings to their correct inclination to the horizontal within a tolerance of ± 0.1° in any direction.

12. Departures from common planetary of twin or multiple bearings shall be within tolerances specified by the Consultants

13. Tighten threaded fixings uniformly to avoid overstressing any part of the bearing. Supply vibration-resistant type fasteners where significant vibration may occur.

14. Bed bearings over their entire area. Voids or hard spots after installation are not acceptable. Care shall be taken to ensure that no air pockets exist below the bearing bottom adapter plate after installation.

15. The bedding material shall be capable of transmitting the applied load to the structure without damage. The bedding mortar thickness shall not be less than 20 mm. If greater than 50 it shall be reinforced. The bedding mortar shall extend beyond the bearing perimeter by at least 50 mm or twice the thickness of the bedding mortar; whichever is the greater. Fall away the top surface of this extension from the bearing to prevent the collection of water around the bearing if applicable.

16. The bedding mortar shall be of sufficient fluidity to ensure that no air gap/pockets exists below the bearing bottom adapter plate. The procedures for the installation of the bedding mortar shall be subject to the approval of the engineer. The contractor shall, at his own costs, carry out a site trial test, for approval by the Engineer prior to bearing installation, to verify the fluidity and performance of the bedding mortar.

17. After installation leave bearings and their surrounding area clean. Remove temporary transit clamps at a time to be agreed upon by the supplier and the Consultant.

18. Upon completion of the installation, certify, in writing to the Consultant, that the bearings have been correctly installed.

3.6 LOAD CELLS

1. At least two Free type (multi-directional) mechanical bearings shall be equipped with load cells for monitoring of bearing loads during construction and up to completion. The Contractor shall design, supply, maintain and operate the system for recording the loads to an accuracy of 5% to the satisfaction of the engineer

3.7 GRADUATED SCALES

1. To monitor displacement and allow the current data to be recorded when structures are inspected; the bearing sliding plates are fitted with graduated scales. It is essential that the latter be positioned so as to optimize visibility for visitors. It is also advisable to set all scales throughout the structure in an identical fashion, so as to facilitate operations.
2. The graduated scales should be fitted to at least one of the bearings located at each of the bridges expansion joints.

3.8 DOCUMENTATION TO BE SUPPLIED WITH THE BEARING

1. The contractor shall provide all necessary documentation for the long term inspection, maintenance, and replacement of the bearings. This shall include full documentation of the design, working drawings, a certificate of compliance from the supplier, third party testing agency (BBA or MPA) certificates, welding certificates, documentation of the load tests, quality records and as installed details, procedures for the inspection of the bearing, procedures for maintenance and a fully detailed method statement for the replacement of the bearings. The documentation shall include risk assessments and appropriate safety information. The as-installed records shall include tabulated bench line measurements that will allow the movement of the structure to be monitored during operation

3.9 SAMPLING, TESTING AND INSPECTION

1. Conformity evaluations of bearings shall be carried out in accordance with EN 1337.
2. The shipment of bearings must be accompanied by certificate of origin confirming that bearing has been manufactured at country of origin.
3. The contractor shall provide at his expense for the testing and inspection of materials and of the completed bearings, in the bearing manufacturer's plant or at an independent test facility approved by the Engineer or his representative, who shall be allowed free access to the manufacturer's plant and test facility.
4. The Contractor shall also provide at his expense for two persons, the engineer or his representative and an additional person from the client body, to carry out a visual

inspection of the bearings in the factory prior to transportation to site. The inspection shall include the following:

(i) An inspection of the individual elements of each of the following types of bearings;

(a) A typical unidirectional bearing

(b) A typical multi-directional bearing

(c) A typical fixed bearing

(d) Any other bearing which is significantly different from the above three

(ii) The bearings will be dismantled and each of the bearing elements will be made accessible for inspection. The bearings will then be re-assembled to be ready for transportation

(iii) Witnessing the testing of a bearing nominated by the engineer at the approved test facility.

(iv) Witnessing the dismantling of the tested bearing and verifying the performance of the individual elements of the tested bearing

5. Prior to the visit, the contractor shall issue all relevant documents including shop drawings and design calculations of each of the manufactured bearings for review by the engineer.

3.10 GUARANTEE

1. Require the General Contractor to provide a written guarantee stating that the bearings have been fabricated such that they will perform satisfactorily within the design range of movement and under the design loads for a fifteen year period from the date of substantial completion. The contractor shall indicate that they have reviewed the installation procedures and find it in accordance with the bearing supplier's recommendations. Provide in the guarantee for the replacement (including supply and installation) of the bearings at no cost to the Owner in the event that the bearings do not perform satisfactorily within the design range of movement and under the design loads. Ensure that the bearings are installed in such a manner that will not void the fabrication guarantee.

2. The contractor shall submit the bearing technical approval document for each type of bearing installed issued by BBA or MPA Stuttgart, which shall indicate the service life of the bearing.