Comparison of AASHTO (US) to European (EN) specifications: Bearings

Location: Burlington, VT

Date: June 25th, 2018

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Agenda

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1 General comparison of state of practice (EU / US)

2 Comparison of bearing specifications

3 Comparison of some technical details

4 Approvals for special products

5 Summary

General state of practice in Europe & USA

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Europe:

- Managed by European Committee for Standardization (CEN)
- One single specification, followed by 34 member countries
- Major initiative made in late 1990s through early 2000s to standardize specifications from different countries (EN members)
- Manufacturers were involved in the process of feedback & review

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United States:

- Managed by AASHTO Committee
- All states maintain their additional state specifications
- Manufacturers can make initial proposal for changes, but not part of voting committees

AASHTO

Observation on U.S practice: Multiple specifications vs. single set of specifications, is the main difference compared to Europe

Managing / updating of specifications in Europe

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- **Membership Relations & Monitoring Committee (MMRC)** with mandatory representation from all member countries – Ensures that interest of all countries is considered
- **National Standardization Body** of each country is responsible to ensure implementation of standardized codes, and to withdraw any conflicting national standards – Ensures that there is one unified code and no conflicting requirements
- **Public review of draft changes** is mandatory, and manufacturers can nominate their representatives as well – Manufacturers can contribute a lot from their experience
- **National delegation principle** requires that all parties are informed of draft changes prior to them being implemented – Ensures transparency, no one to one closed communication

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AASHTO

Standardizing of specifications in Europe took a decade to be implemented, but is now looked back as a huge success story

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Comparison of codes for Structural bearings

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AASHTO LRFD	EN1337 (Parts 1 to 11)
Divided in two codes: (1) Design (Ch.14): Providing loads & design guidelines (2) Construction (Ch.18): Covering fabrication, testing, installation & inspection Both codes address all bearing types: • Elastomeric bearings • Pot bearings • Disc bearings • Spherical & rocker bearings	Divided in 11 separate specifications: (1) General loads & design rules (2) Sliding elements (3) Elastomeric bearings (4) Roller bearings (5) Pot bearings (6) Rocker bearings (7) Spherical & cylindrical bearings (8) Guided bearings (9) Corrosion protection (10) Inspection & maintenance (11) Transport, storage & installation

The arrangement scheme of the codes in U.S and Europe is completely different. European code parts 3 thru 7 only cover items that are specific to those bearings

Comparison of Bearing specifications

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1 Level of detail of bearing specifications

2 Uniformity (standardization) of specifications

3 Updating the specifications & Participation of bearing manufacturers

Comparison of Level of detail in AASHTO & EN

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Below table shows the number of pages per bearing type, in AASHTO & EN specifications:

Product	AASHTO Design (Ch.14)	AASHTO Construction (Ch.18)	AASHTO Total	EN 1337
General *(design, fabrication, testing, installation, inspection)*	7 pages	9 pages	**16 pages**	**78 pages**
Elastomeric Bearings	16 pages	2 pages	**18 pages**	**98 pages**
Pot Bearings	5 pages	8 pages	**13 pages**	**60 pages**
Disc Bearings	2 pages		**10 pages**	**-**
Spherical Bearings	2 pages	2 pages	**4 pages**	**26 pages**

The EN philosophy is to have "prescriptive" spec for standard bearings and components, and "performance" based spec for special / proprietary products

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AASHTO: Observation on multiple specifications

There are some inconsistencies which could be deliberated in future revisions of AASHTO:

Examples:

- **Within AASHTO Design & Construction specifications:**

Stainless steel flatness tolerance:

Construction section 18.3.3.1 (Fabrication) requirements differ from Requirements of table 18.1.4.2 fabrication tolerances.

- **Between AASHTO & State specifications:**

Properties of PU disc for disc bearings:

- AASHTO allows durometers 45 to 65, while NYSDOT allows 57 to 67.
- Requirements on physical properties like ultimate elongation, tensile stress differ between AASHTO & state specifications.

Consistency among DOT & AASHTO Specifications would eliminate misinterpretation and risks

EN: Unified standard requirements

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- National member bodies release only addendums covering topics not included in the EN code may be used locally.

- All 34 countries follow the EN1337 specification for design, manufacture, testing, installation, maintenance of structural bearings

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Advantages:

- ✓ The costs for each state, required in maintenance and updating of their local specifications can be greatly eliminated.

- ✓ Mistakes due to incomplete specifications, misinterpretation of requirements, conflicting clauses can be reduced.

- ✓ The experience available from CEN standardization project can help US a lot in implementing it even more efficiently.

The ‘34 countries - 1 code’ model, could be applied to ‘50 states - 1 code’

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European specification encourages proposals for changes, from manufacturers..

The European Committee for Standardization officially invites manufacturers to submit their proposal of changes to the specification. Below is an example of working draft submitted by mageba in 2017:

CEN/TC 167/WG 1 **N 728**

CEN/TC 167/WG 1
Revision of EN 1337
E-mail of Secretary: damir.zorcec@din.de
Secretariat: DIN

Working draft prEN 1337-8 after Munich (WG 1) and Karlsruhe (Editoral Group) meeting

Date of document	2017-06-07
Expected action	Info

Over the years, due to active participation of manufacturers in this process, the EN specification for bearings and joints has advanced prolifically

Status of updates made to the AASHTO Bearing Design specification

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Below is the summary of updates made to section 14, since 2010 (5th edition of AASHTO):

➢ 2017, 8th edition

SECTION 14 REVISIONS

Changed Articles

The following Articles in Section 14 contain changes or additions to the specifications, the commentary, or both:

14.5.6.9.7a 14.5.6.9.7b

2017

Only minor editorial changes

➢ 2015, 7th edition

SECTION 14: JOINTS AND BEARINGS

C14.6.3.1

2015

Update to exp. joints but no updates to bearings

➢ 2012, 6th edition

SECTION 14 REVISIONS

Changed Articles

The following Articles in Section 14 contain changes or additions to the specifications, the commentary, or both:

14.3	14.7.5.3.3	14.7.6.1	14.7.6.3.3	14.7.6.3.5b
14.6.3.2	14.7.5.3.6	14.7.6.3.2	14.7.6.3.5a	14.7.6.3.6

2012

Minor design updates to elastomeric bearings

In the last 10 years, there have not been significant update to the section 14 (Bearings), especially to HLMR bearing specifications

Summary: Possible solutions

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Current state of practice	Potential problems	Possible solution
AASHTO Design (Ch.14) & Construction (Ch.18 & 19) Specifications not detailed enough for bearings & expansion joints	• Leaves lot of scope for individual interpretation • Creates technical problems in ongoing projects	Like the major European initiative (CEN), a technical committee of: • *DOTs* • *Experts from research & academic area* • *Major manufacturers* can be convened to evaluate the possible changes / additions to AASHTO, and to make DOT specifications consistent with AASHTO requirements
Several DOT specifications, with some requirements that contradict with AASHTO specifications	• Creates potential for non-conformances that could be avoided • Leads to bridge engineers specifying incorrect requirements for bearings and joints	

An EN style project to ‘detail and harmonize’ the current AASHTO & DOT specifications can be of immense benefit to all DOTs

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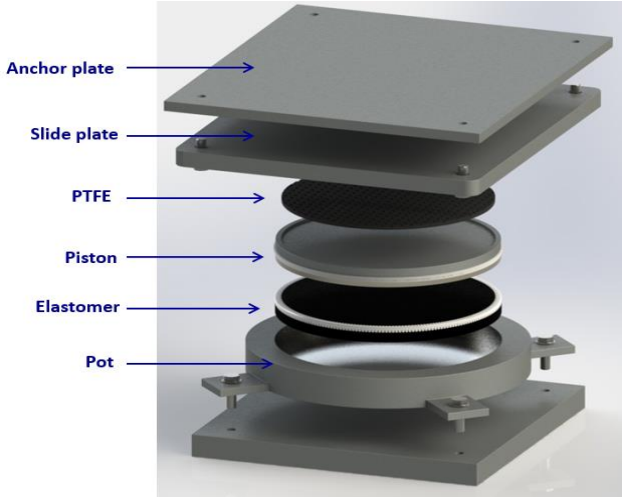
Pot Bearings – Sealing rings

Overview of Pot bearings

- Widely used in Europe
- In U.S, failures have occurred in the past due to installation errors, or poor fabrication / quality control
- For high horizontal loads and rotations at low vertical loads, pot bearings are a very good solution.

Sealing ring

- Most critical element in a pot bearing
- Failure of sealing ring results in elastomer leakage, thereby compromising the rotation performance of bearing
- Mostly commonly used sealing are brass and POM (Poly-Oxy-Methylene)



Pot bearings are widely used in Europe and Asia, while in U.S, the market is split between pot and disc bearings

Sealing rings – U.S Practice

U.S (AASHTO)

- Brass sealing is explicitly specified, however the code mentions "*other sealing systems*" may be approved by the Engineer.
- "*European materials would require verification testing*" statement needs to be updated.

14.7.4.5—Sealing Rings

14.7.4.5.1—General

Brass rings satisfying the requirements of either Articles 14.7.4.5.2 or 14.7.4.5.3 may be used without testing to satisfy the above requirements. The Engineer may approve other sealing systems on the basis of experimental evidence.

C18.3.3.2.2

Sealing rings are presently made from brass in the United States. Attempts were made to use PTFE in the past but these were unsuccessful because the PTFE ring squeezed out through the gap between the pot and the piston and, thereafter, was ineffective as a seal. However, certain proprietary materials have also been used in Europe with success. They would require verification testing before being accepted in the United States.

EN (Europe)

- Allows use of brass, POM, stainless steel seals.
- Specifies "accumulated slide path" for each seal type, based on extensive testing

The sealing ring material and comparisons in the EN code have been specified based on extensive test results

Comparison: Brass vs. POM sealing

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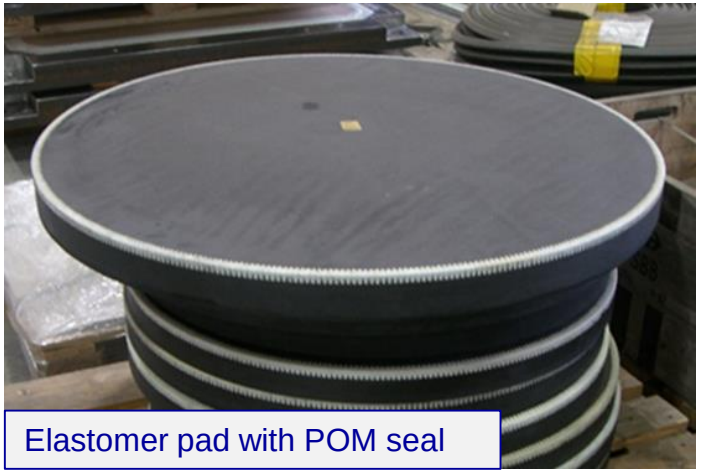
Brass sealing

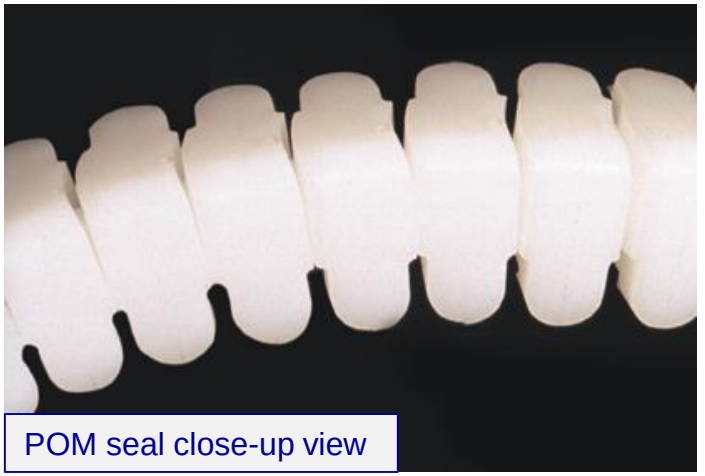
- Metal to metal contact (friction & wear)
- Single element (no redundancy / flexibility)

POM sealing

- No metal to metal contact (low wear & friction)
- Large number of individual elements – adaptation to all deformations
- Based on test results, section 5.4 of EN 1337-5 clearly classifies the “accumulated slide path” of sealings:
  - *Brass seal = 1,000m [3,280 ft.]*
  - *POM seal = 2,000m [6,561 ft.]*
- Not a patented product = Any supplier can use it



Elastomer pad with POM seal



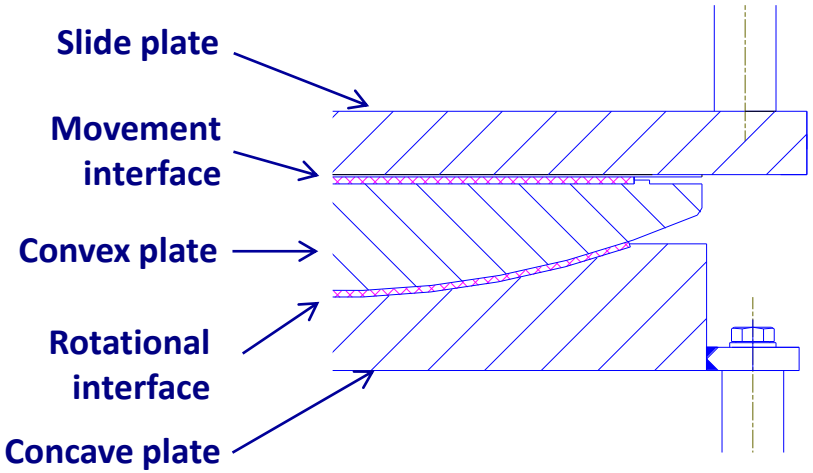
POM seal close-up view

As sealing technology with double sliding path is available openly, it could benefit owners greatly, by utilizing POM seals on Pot bearings

Spherical Bearings – Horizontal force

Overview

- Typically used for high rotation and high vertical load applications
- No compression element (PU disc / elastomer pad)
- Can be preset to any rotation
- Ideal for high rotation-low vertical load applications



Vertical load capacity: 56,000 kips

Spherical bearings have been successfully used worldwide for several decades

Horizontal force transfer

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U.S practice

- Horizontal force transferred through curvature (spherical surface)

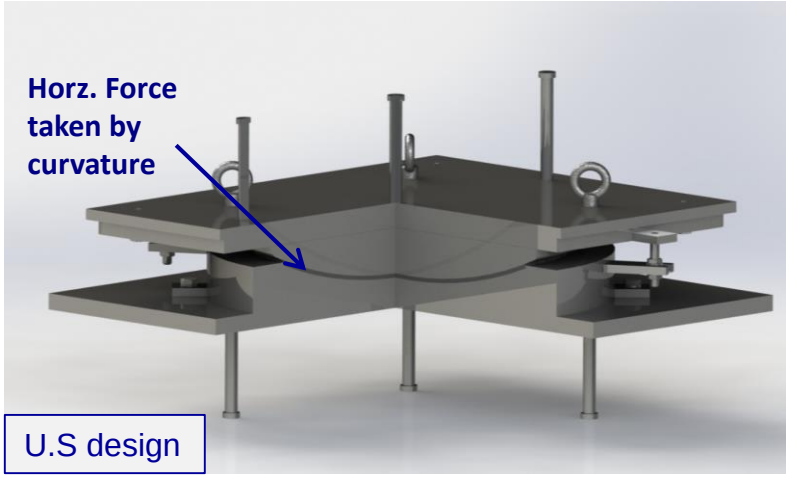
Application

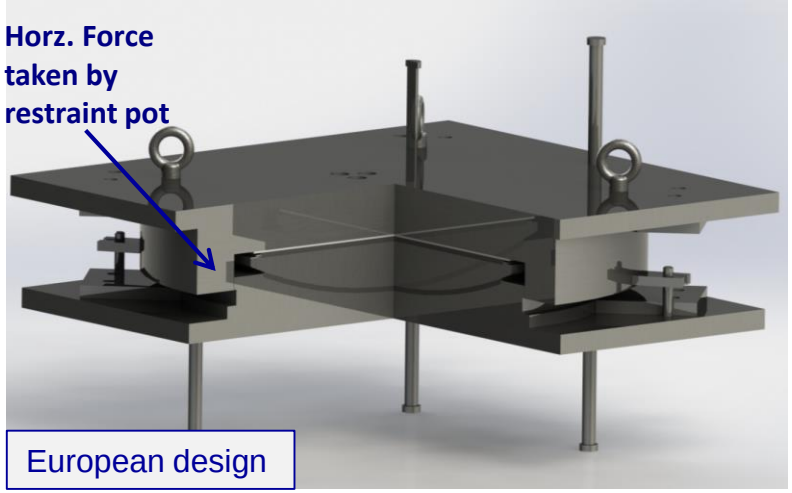
- O.K for free bearings (no horizontal force, only friction)
- For guided & fixed bearings, high 'horizontal / vertical load' ratio can be unstable & risky.
- Fixed bearings are pushed / pulled over the rotational surface by the entire span
- AASHTO commentary also notes that an external restraint system is a more reliable method:

14.7.3.3—Resistance to Lateral Load

C14.7.3.3

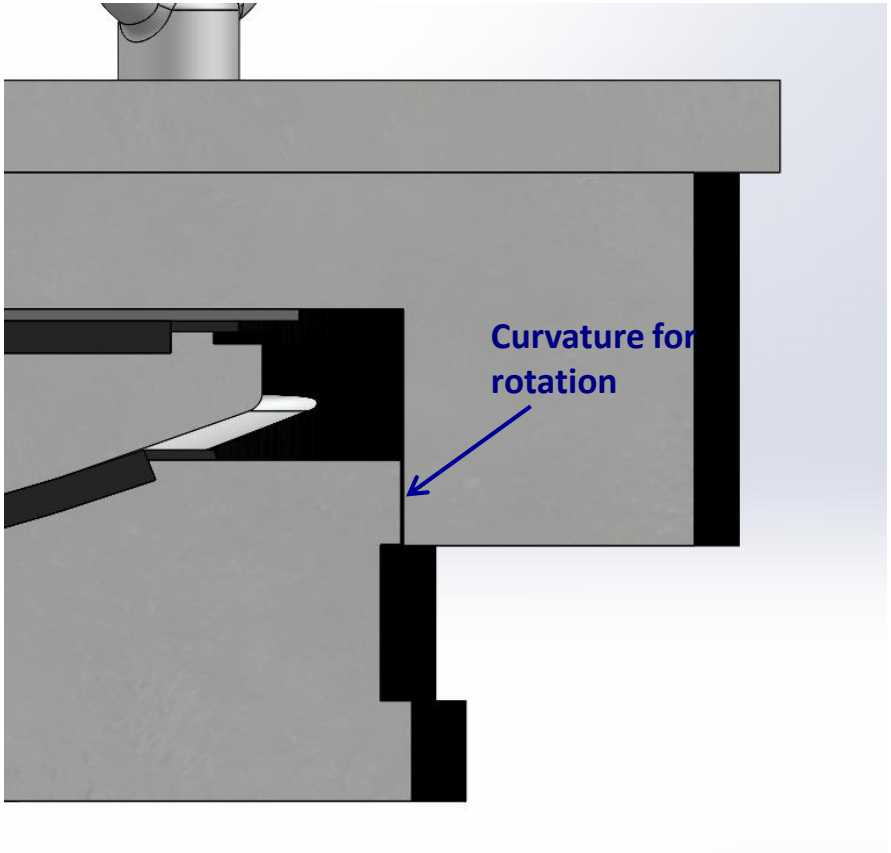
The geometry of a curved bearing combined with gravity loads can provide considerable resistance to lateral load. An external restraint is often a more reliable method of resisting large lateral loads at the service and strength limit states, and at the extreme event limit state when the bearing is not intended to act as a fuse or irreparable damage is not permitted.



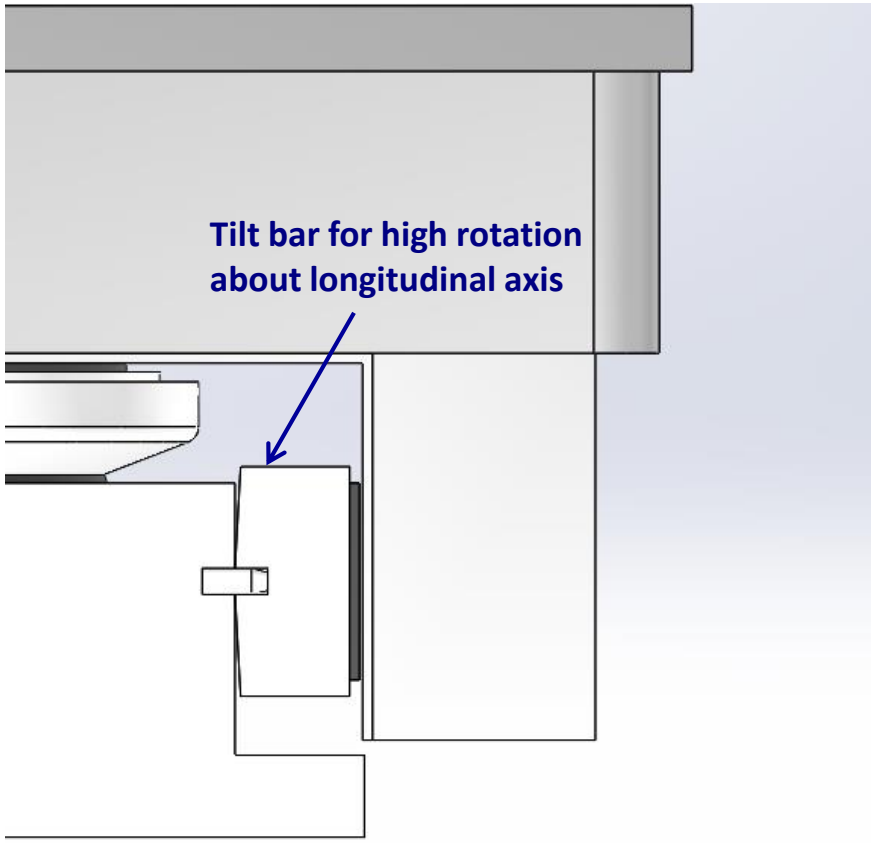


Horizontal restraint with curvature works well for low 'horizontal / vertical load' ratios, but it may be beneficial that quantitative limits be defined in AASHTO for both solutions

Horizontal restraint detail



Fixed Bearing horizontal restraint detail



Guided Bearing horizontal restraint detail

External restraint system eliminates any concern of unstable bearings

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Overview – State of Approvals & Innovation in Europe

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- **Continuous innovation is critical on bearings and joints**, which are products with wear components *(like sliding materials, springs etc.)* and fatigue loading.

- The European Organization for Technical Assessment **(EOTA) grants approvals for special products**

- **Standalone approvals are provided by a central body**, and **recognized by all member countries** that follow the EN design standards

- Approvals from the EOTA **require extensive testing and quality control**, and third party inspections

The EOTA approval system has encouraged mageba and other manufacturers active in Europe, to innovate several state of the art products.

Example approval from the ETA: mageba Robo®slide

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Zulassungsstelle für Bauprodukte und Bauarten
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Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)

Deutsches Institut für Bautechnik
DIBt

Mitglied der EOTA
Member of EOTA

European Technical Approval ETA-08/0115

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung *Trade name*	mageba ROBO®SLIDE L2 Kalottenlager *mageba ROBO®SLIDE L2 Spherical bearing*
Zulassungsinhaber *Holder of approval*	mageba SA Solistraße 68 8180 Bülach SCHWEIZ
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	Kalottenlager mit besonderem Gleitwerkstoff *Spherical bearing with special sliding material*

In the U.S, absence of central approval system forces manufacturers to go to each of the 50 states individually, which ultimately discourages innovation

What could be adapted in the U.S?

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- **Special approvals for innovative products**

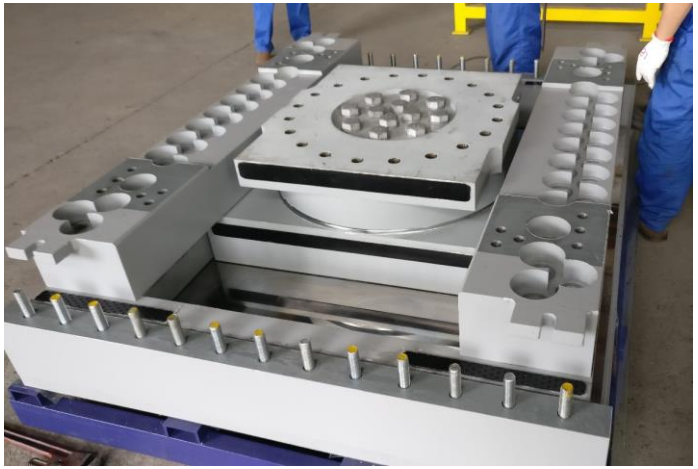
A parallel ‘standalone’ approval system *(independent of the specificaiton)* for special products will encourage innovation and drive the technology forward

- **Less red tape, more centralized system**

Manufacturers need a system where they can spend more time in developing a product, rather than in getting it approved

- **Framework of such system already exists**

The existing ETA system of Europe can serve as a good starting base, which can be studied, evaluated and emulated to the U.S market for bearings and expansion joints



Manufacturers can certainly help, but initiative needs to come from DOTs, who will be the end users and ultimate beneficiaries of innovative products

Summary

Topic	Problem	Possible solution
Design and Construction specifications on bearings	• Very brief, with scope for misinterpretation • Multiple DOT specifications, with some contradictions to LRFD requirements	Similar to EN system, a technical committee where manufacturers are also represented and heard, in addition to DOTs and research experts, could be formed, with the goal of detailing and harmonizing specifications
Technical details	• Pot bearings – Inclusion of POM sealing • Spherical bearings – Include quantified limitation criteria on spherical curvature vs. external restraint system	• Opens doors for DOTs to require bearings with higher durability • Eliminates unstable solutions, provides safety to DOTs
Approvals for special / new products	• No centralized approval system, creating an onerous state by state approval process	DOTs to contemplate a central 'standalone' approval system for special / innovative products

With all DOT's being the end users of bearings and expansion joints, we believe that above initiatives will yield significant economical and technical benefits

Thank you for your attention

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