Next Generation Flexible Expansion Joint

POLYFLEX® Advanced PU
from certification to installation
POLYFLEX® Advanced PU flexible plug joint system

Introduction

Asphaltic plug joints

Mat joints

Aluminium strip seal joint

Bolted finger joints

Pictures we often see on small movement joints after a few years
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Introduction

Expansion joints, whether on big or small bridges, have the reputation of being some of the most problematic parts of the bridges. This is mainly due to the dynamic impact loading, as well as the fact that expansion joints are at the road surface. Any maintenance, refurbishment or replacement work automatically results in lane closures and thus, traffic jams.

Problems that are encountered most often:

- Fatigue damage of non-fatigue proofed materials
- Insufficient anchoring
- Excessive wear and tear (e.g. of rubber and aluminium materials)
- Substantial water ingress, leakage
- Plastic deformation at high temperatures, cracking at low temperatures
- Safety concerns when steel parts protrude through the damaged joints into the carriageway
- High noise generation and low driving comfort

Even small movement expansion joints need highest attention during selection, design, fabrication, installation and maintenance
Challenge to develop a new expansion joint system that reduces all of the mentioned problems, for:

- Long maintenance-free working life
- No spontaneous / catastrophic failure mechanism
- Maintaining full water-tightness
- Favorable behavior at very low and very high temperatures
- Relatively versatile movement range (e.g. up to 135 mm)
- Maximized driving comfort and low noise generation
- Minimized installation effort, time and errors

How could a perfect expansion joint look like?
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Description of system

1) Structure (abutment/bridge)
2) Substructure in polymeric concrete
3) Cover plate
4) Steel angle
5) Bridge water proofing
6) Stabilizing element (only > PA50)
7) POLYFLEX® material with high performance PU
8) Anchorage (only secondary to keep angle in place)
9) Surfacing - Asphalt or concrete

Overview of the various components of the polyurethane based system
How can we overcome the problems of a classical bituminous plug joint such as:

1. **Lack of water tightness**
2. Low durability (often << 10 years!)
3. Bump in summer, slack in winter
4. Plastic deformation at high temperatures and at locations of higher horizontal loads (braking and acceleration forces)
5. Rutting effects

-> **100% water tightness proven by Water tightness test at BAM Berlin**

Not only the PU material needs to be watertight, but the **whole system**
How can we overcome the problems of a classical bituminous plug joint such as:

1. Lack of water tightness

2. **Low durability** (often << 10 years!)

3. Bump in summer, slack in winter

4. Plastic deformation at high temperatures and at locations of higher horizontal loads (braking and acceleration forces)

5. Rutting effects

- **Full size 1:1 testing** for movements at temperature ranges from *-40°C to +60°C*
- > **7,500,000 cycles** with 1 mm amplitude at 5Hz

*Fatigue testing at BAM Berlin confirmed extended service life*
How can we overcome the problems of a classical bituminous plug joint such as:

1. Lack of water tightness
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5. Rutting effects

- **Material remains stable** from low up to very high temperatures
- **Stabilizers for larger types** keep the PU at level

Temperature dependent dynamic-mechanical behavior of Polyflex tested at German Federal Institute BAM, Berlin
How can we overcome the problems of a classical bituminous plug joint such as:

1. Lack of water tightness
2. Low durability (often << 10 years!)
3. Bump in summer, slack in winter

4. **Plastic deformation** at high temperatures and at locations of higher horizontal loads (braking and acceleration forces)

5. Rutting effects

- **Full size 1:1 testing** with 150 kN load for 3,030 Cycles at 45°C

- Deformation < 0,5 mm; no damages

- **Complete elastic recovery**
How can we overcome the problems of a classical bituminous plug joint such as:

1. Lack of water tightness
2. Low durability (often << 10 years!)
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4. Plastic deformation at high temperatures and at locations of higher horizontal loads (braking and acceleration forces)
5. Rutting effects

-> Resistance to rutting is far superior

Further long-term testing to prove durability
POLYFLEX® Advanced PU flexible plug joint system
Rutting test performed at MAPAG Testing Institute, Austria

- Comparison with traditional asphaltic plug joint
- Testing performed according to EN 12697, Part 22

Asphaltic plug joint after 100 cycles at 60°C (140°F) Extreme rutting, deformations up to 3 cm (1.2”)

New Polyflex® joint after 30,000 cycles at 60°C (140°F). No rutting, no deformation.

Resistance to rutting is far superior over traditional asphaltic plug joints
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European Technical Approval ETA

CUAP process was followed:

Due to the lack of specific EU regulations, an extensive approval process was required in order to obtain a European Technical Approval (ETA) and to permit the application of the CE-label to the product.

This process, called CUAP, was completed in June 2012 – the first ETA awarded for an expansion joint.

CUAP = process that assures that all European CEN members approve the technical performance according to specific requirements
Types of Polyflex® joint according to the *European Technical Approval*

<table>
<thead>
<tr>
<th>Type</th>
<th>Total Movement mm</th>
<th>Movement Elongation mm</th>
<th>Movement Compression mm</th>
<th>Thickness of PU-layer mm</th>
<th>Width in starting position mm</th>
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<tr>
<td>PA 15</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>40</td>
<td>280</td>
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<tr>
<td>PA 30</td>
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<td>10</td>
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<td>350</td>
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<td>PA 50</td>
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<td>90</td>
<td>45</td>
<td>60</td>
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- Table shows examples for general design, width may be interpolated
- For individual cases, width and thickness are determined based on required movement
- All types are designed for a vertical displacement of ± 10 mm, allowing for bearing replacements
- Movements are indicated in SLS, for ULS higher deformations are permitted
A whole series of testing was undergone, especially fast movements due to seismic events were of interest -> all testing successful
Every region has specific requirements, e.g. Nordic countries have issue with spikes used in the winter.

Testing at the state laboratory VTI at Linköping, Sweden in June 2015 was performed to simulate this new requirement: **no abrasion on the joint was found at all** (elastic performance, memory effect)

**Resistance against spikes and the elastic performance of the material**
Inclusion in Australian bridge code:

Flexible plug joints are now explicitly included in the AS5100.4-2017:

19.2 Joint types

Joints shall be categorized as follows:

(a) Compression seals.

(b) Strip seals.

(c) Saw tooth.

(d) Finger plates.

(e) Flexible plug.

(f) Modular.

(g) Other.

The characteristics and performance history of a particular joint shall be reviewed to determine the suitability of the joint for a specific installation.
Compliance with Australian Regulations

**Temperature:**

Verifications for the European Technical Approval for -40°C thru +60°C full compliance is given to AS5100.2-2017, Table 18.2

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**Contact Stress:**

Verifications as per above comply fully with AustRoads Guide to Pavement Technology, Part 2 and Main Roads WA Engineering Note 9

**Structural Components:**

After review for ULS and SLS requirements acc. to AS5100.4 cover plate dimensions and steel grade were adapted to the Australian requirements for full compliance
Installation in an existing structure
Cutting of road surfacing
Installation
Cleaning, sandblasting, primer application
Installation
Casting of substructure
Installation
Installation of angles
Installation
Mixing of material
Installation
Placing of POLYFLEX® Advanced PU mixture
Installation
Perfectly smooth finish prevents vibrations/noise
Installation
Easily adaptable to suit structure geometry
Installation

... for vertical and horizontal bends
Reference Projects in Australia
POLYFLEX® Advanced PU

Judd Street PERTH (WA) Polyflex, Type PA90, May 2015
Reference Projects in Australia
POLYFLEX® Advanced PU

South Western Highway, PEMBERTON (WA), Type PA 40, November 2015
Reference Projects in Australia
POLYFLEX® Advanced PU

Harvey Waterpark Bridge, Bunbury (WA), Type PA 40, October 2017
Henry Hudson Parkway, New York, Type PA 30, Oct. 2014
Shimomura Bridge near KYOTO, Type PA 50, May 2015
Reference High Speed Railway in Austria
POLYFLEX® Advanced PU

right: before ballast
below: upstand at cable ducts

ÖBB Kugelsteinbrücke, March 2016
Reference Architectural Application
POLYFLEX® Advanced PU

Central Station Zürich, Schweiz, 2015
Reference Tunnel Application
POLYFLEX® Advanced PU

2nd Bosporus Tunnel, Istanbul-Turkey, 2016
Thank you for your attention!