IEC Elastic Polyurethane Expansion Joint (PUF joint)

An PUF Elastic Polyurethane Expansion Joint was supplied and installed by IEC and serviced at ramifying highway roads in Yuguang expressway, Chongqing, China,2016

General

According to the European standard ETAG 032 code, a Flexible Plug Expansion Joint (FPEJ) is defined as an in-situ poured joint, consisting of a specially formulated flexible material (comprising binder and aggregates). This material not only forms the surfacing but is also supported over the deck joint gap by thin metal plates or other suitable components.

Traditionally, binder materials used for these joints have predominantly been bitumen-based, often referred to as modified bitumen. However, modern advancements in material science have introduced polyurethane as a superior alternative for asphalt plug expansion joints in bridge construction. Polyurethane is highly favored due to its exceptional durability, flexibility, and resilience. Unlike modified bitumen, polyurethane can endure extreme temperature fluctuations without cracking or deforming, making it highly resistant to weather-induced damage. Its outstanding elasticity allows it to accommodate the dynamic movements of bridges—such as expansion, contraction, and vibrations—while maintaining the joint's structural integrity. Furthermore, polyurethane's superior adhesive properties enable a strong bond with asphalt and other construction materials, resulting in extended service life and significantly reduced maintenance costs. This makes it a more cost-effective and sustainable solution for ensuring the long-term stability of bridge structures.

Building upon these principles, IEC has developed a proprietary Elastic Polyurethane (PUF) Expansion Joint, known as the PUF series. This product is particularly well-suited for noise-sensitive environments or locations with substantial transverse movement, offering an optimal solution for modern bridge expansion joint requirements.


PUF polyurethane joint supplied and installed by IEC at Yuguang expressway, Chongqing, China 2020


Installation of PUF joint for Changshen Expressway, Hangzhou Section in Zhejjiang, China 2022

Merits:

- **Driving Comfort and Low Noise:**
  The seamless design of the PUF joint ensures that the beam deck remains free from visible gaps, which significantly reduces the impact experienced by vehicles passing over the joint. The excellent elasticity and vibration-damping properties of polyurethane effectively absorb the shock and vibration generated by traffic, enhancing driving comfort while minimizing noise.

- **Longevity:**
  Polyurethane is a highly durable synthetic polymer, offering stable performance and ease of processing. It possesses exceptional resistance to wear, oil, water, extreme temperatures, fatigue, and corrosion. Additionally, its inherent durability allows for easy maintenance and repairs, resulting in an extended lifespan for the expansion joint.
- **Impermeability:**
  Polyurethane has superior adhesion properties when bonded with concrete and steel, creating a continuous waterproof barrier. This impermeable layer effectively integrates with the roadbed's waterproofing system, preventing water ingress and protecting the bridge deck from damage caused by moisture.
- **Minimal Block-Out Depth:**
  The PUF joint's shallow block-out depth minimizes damage to the beam structure and reduces the need for extensive alterations to the beam design. This feature makes it especially suitable for thin-walled beam structures, preserving the integrity of the existing infrastructure.
- **Accommodation of Exceptional Transverse Movement:**
  In scenarios where substantial transverse movement is required, such as at complex intersections on expressways, the PUF joint can effectively handle both longitudinal and transverse movements simultaneously. Its flexibility ensures that the joint adapts to dynamic structural shifts without compromising performance.
- **Quick and Easy Installation/Repair:**
  The PUF joint system is designed for fast and efficient installation. The polyurethane material can be cast in one continuous process, requiring minimal specialized equipment and labor. Additionally, traffic can resume within 48 hours after casting, making the joint ideal for projects requiring minimal disruption.

Materials

- Polyurethane Elastomer (PUF)

  Primary Material: Polyurethane is a synthetic elastomer known for its outstanding mechanical properties, including high elasticity and resistance to wear, temperature extremes, and chemicals.

  Elasticity: Polyurethane offers superior flexibility, allowing the joint to accommodate bridge movements such as expansion, contraction, and vibration. It can handle both longitudinal and transverse movements effectively.

  Temperature Resistance: The PUF material is highly resistant to cracking or deformation due to significant temperature fluctuations. It performs well in both hot and cold environments, withstanding a temperature range typically between -60°C and 250°C.

Durability: Polyurethane provides excellent resistance to aging, fatigue, and environmental wear, ensuring the long-term performance of the joint even under heavy traffic loads.

Adhesion Properties: It bonds effectively with both asphalt and concrete, forming a continuous and seamless waterproof layer that prevents water penetration and ensures the structural integrity of the bridge.

- Aggregates (In Case of Asphalt Plug Joints)

Polyurethane is often combined with aggregates to form a flexible plug expansion joint. The aggregates, which may include crushed stone or other mineral fillers, provide added structural stability and help distribute loads across the joint.

Binder-Aggregate Mixture: The mixture of polyurethane and aggregates is in-situ poured to create a flexible surface capable of absorbing traffic loads while allowing movement within the joint.

- Steel Plates (Optional for Reinforcement)

In some configurations, thin steel plates may be used to reinforce the joint. These plates are placed over the deck joint gap, supported by the polyurethane material, ensuring load distribution while allowing movement.

Metal Reinforcement: Some designs incorporate steel reinforcements or loops to enhance the mechanical strength and load-bearing capacity of the joint, particularly in high-traffic or heavy-load areas.

- Adhesives/Sealants

In cases where polyurethane is bonded to the surrounding concrete or steel structures, high-strength adhesives or sealants may be applied to improve adhesion and ensure a tight bond. These materials help create a watertight seal, preventing water infiltration that could damage the underlying structure.

- Surface Coatings (Optional)

For additional protection, the surface of the polyurethane joint may be coated with anti-slip or wear-resistant finishes to improve vehicle traction and enhance the longevity of the joint under continuous use.

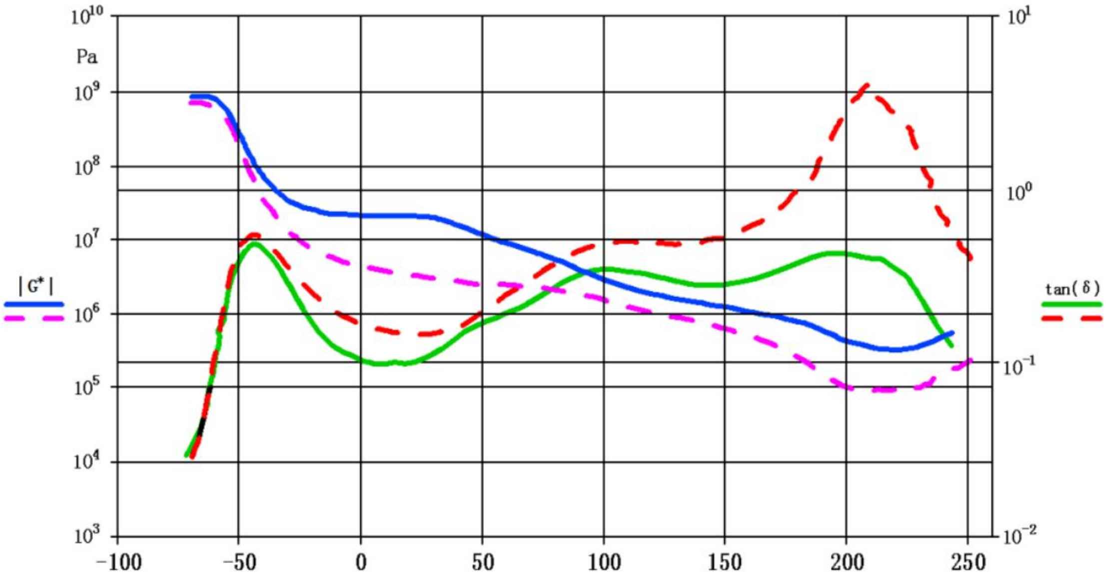
Testing

IEC conducted comprehensive in-house, full-scale testing of the PUF expansion joint, simulating real-world wheel traffic conditions. The testing spanned 3,030 hours (126 days), covering a wide temperature range from -60°C to 250°C. The results demonstrated that both the shear modulus (G) and the loss factor (tan δ) performed optimally, maintaining ideal levels throughout the testing period, as illustrated in the accompanying image. These findings confirm the PUF joint's ability to withstand extreme conditions while retaining its mechanical properties.

Test pieces of PUF-80 and PUF-100 with a length of 4m were tested at shear movement of ±40mm under open temperature 35℃

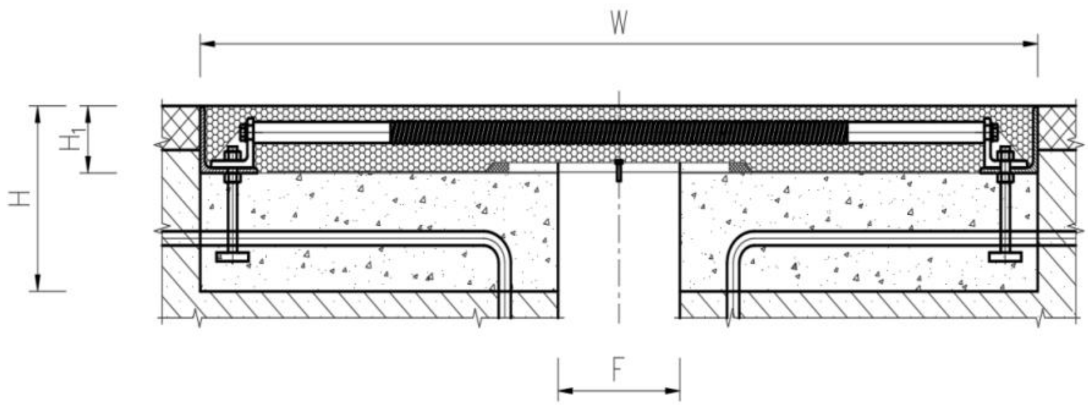
Test pieces of PUF-80 with a length of 1m were tested in-house with contact pressure of 0.95MPa, 150kN loading. Max. Doformation was measured less than 0.5mm.

IEC carried out type testing of full PUF joint assembly subject to scenario simulating actual traffic load and frequency in 2017



Relationship between shear modulus G and loss factor tanδ concluded from testing

Technical Data



Section view of PUF joint

Technical data sheet

code	movement(mm)	beam gap	PUF joint size		block-out depth
		F(MM)	W(MM)	H1(MM)	H*(MM)
PUF40	40	30-40	450	60	160
PUF60	60	30-60	550	60	180
PUF80	80	52-80	700	60	200
PUF100	100	60-100	850	60	220

* H can be variable according to project requirement)

Following chart reveals the physical properties of PUF joint.

items		unit	requirement
solid content		%	≥99.5
hardness		IRHD	65±5
elasticity modulus		MPa	≤2.5
tensile strength		MPa	≥10
elongation at break		%	≥650
tear strength		N/mm	≥15
brittleness temperature		℃	≤-50
peel strength (with steel plate)，-40±2℃,23±2℃， +60±2℃		N/MM	≥8
tensile strength after bonding with concrete， -40±2℃,23±2℃， +60±2℃		MPa	≥1.5
Leveling		h	≥0.5
surface drying time		h	≤2
body drying time		h	≤12
aging	appearance	-	no crack
	hardness	IRHD	±5
	tensile strength	%	±20%
	elongation at break	%	±20%

Properties of polyurethane

Consult IEC engineers for details.

Suitable applications

1. **Bridges and Overpasses**

- Ideal for accommodating thermal expansion and contraction, as well as dynamic movements caused by traffic loads.
- Particularly effective in urban flyovers, highways, and expressways where high traffic demands seamless driving comfort and durability.

2. **Noise-Sensitive Areas**

Perfect for use in locations requiring noise reduction, such as residential zones, urban centers, and areas near hospitals or schools. The joint's flexibility reduces vibration and impact noise.

3. **Extreme Temperature Zones**

Suitable for regions with significant temperature fluctuations, ranging from very cold climates to extremely hot conditions. The polyurethane material maintains performance under a wide temperature range (-60°C to 250°C).

4. **Complex Intersections and Ramps**

   Effective in accommodating significant transverse and longitudinal movements found in intersections, curved ramps, and multi-level road networks.

5. **Industrial Areas**

   Applicable in bridges located near industrial facilities where exposure to oil, chemicals, and other harsh substances requires a joint with excellent chemical resistance.

6. **High-Traffic Bridges**

   Optimal for heavily trafficked roads and bridges, as the joint can withstand continuous loading and dynamic forces without compromising performance.

7. **Coastal or Marine Environments**

   Suitable for bridges and viaducts near water bodies due to its impermeability and resistance to water ingress, which protects against corrosion and extends the lifespan of the structure.

8. **Thin-Walled Beam Structures**

   Specifically advantageous for bridges with thin-walled beams where shallow block-out installation minimizes structural modification and damage.