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General information about Bridge Expansion Joint

Introduction

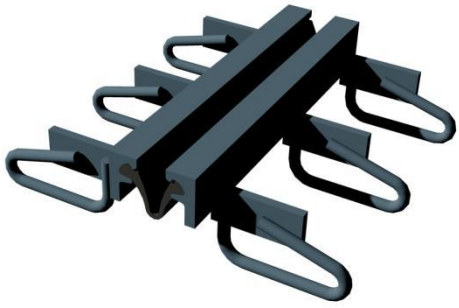
Bridge expansion joints are essential components that ensure uninterrupted traffic flow between structures while accommodating movement caused by shrinkage, temperature variations, and other forces in reinforced and pre-stressed concrete, composite, and steel structures. These joints play a critical role in distributing loads and ensuring safety over gaps between bridge decks or abutments.

In addition to their structural function, expansion joints must minimize noise, particularly in urban settings. Water tightness is also crucial to prevent water ingress into the substructure. Design considerations should aim for ease of replacement with minimal disruption to traffic.

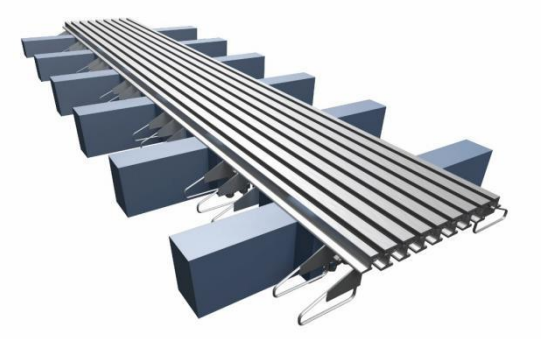
Types of Expansion Joints

Various types of bridge expansion joints accommodate movements ranging from 10 mm to 2,000 mm. The following six major types of expansion joints are part of IEC's supply scope:

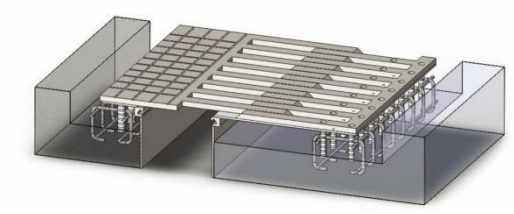
1. **Stripseal Joint (Single-Gap or Nosing Joint)**
2. **Modular Expansion Joint (MBJS as per AASHTO)**
3. **Finger Expansion Joint**
4. **Mat Expansion Joint (Reinforced Rubber)**
5. **Asphaltic Plug Expansion Joint**
6. **Railway Expansion Joint**



Stripseal expansion joint



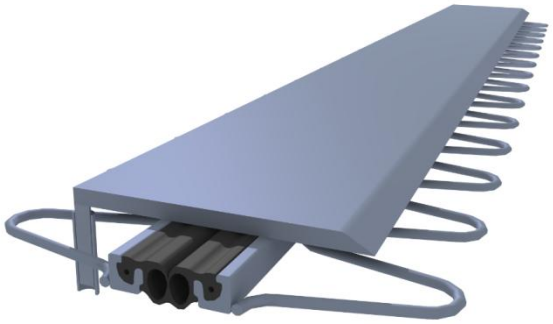
Modular expansion joint



Finger expansion joint

Mat expansion joint (Reinforced rubber)

Asphaltic Plug expansion Joint

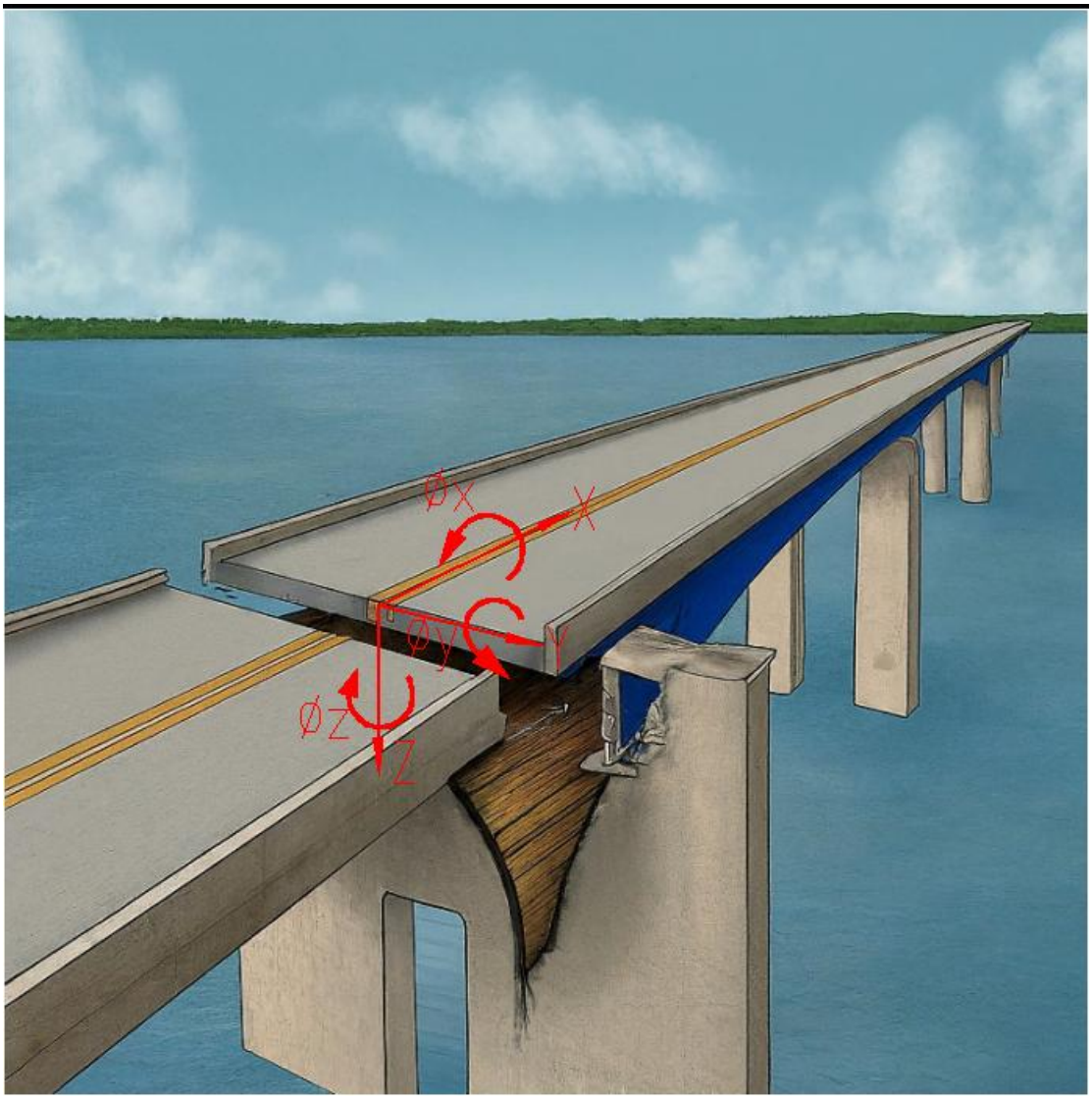


Railway expansion joint

Calculation of movements of expansion joint

The movement of expansion joints depends on bridge size and bearing arrangement. Typically, joint design focuses on horizontal translation orthogonal to the joint. However, all translations and rotations must be considered to ensure displacements remain within the joint's limits.

Movement can result from temperature variations, external loads, and the natural shrinkage or creep in concrete or composite structures. These movements should be calculated during the structural analysis phase and are generally the responsibility of the consultant or designer.



An illustration showing the location and function of bridge expansion joint
(permissible movement/rotation in 6 degrees)

Corrosion prevention

Corrosion prevention is vital for ensuring the longevity of expansion joints and protecting the entire bridge structure. At IEC, standard corrosion prevention procedures for stripseal, modular, or finger joints include:

- **Exposed Steel Surfaces**:

  - Blast cleaning to Swedish Standard SA2.5 for derusting
  - Hand cleaning to remove dirt, rust, mill scale, or oil stains
  - Coating applications:

    1. Primer: Zinc-rich epoxy paint (min. 60 µm)
    2. Final coat: Acrylic aliphatic polyurethane paint (min. 80 µm, applied 2-3 times)
    3. Total dry film thickness: 240-320 microns (finish coat: 60 microns)

- Coating color per RAL 7042 unless otherwise specified
- **Hot-Dip Galvanizing**: Available upon request according to ISO 1461:2009 standards, or as part of a duplex system for added reliability.

- **Non-Exposed Steel Surfaces**:
  Similar procedures as for exposed surfaces, but with two coatings and a minimum thickness of 120 microns.
- **Temporary Devices**:
  Epoxy paint (min. 50 µm) applied post-shot blasting, with colors such as blue or red.
- **Bolts**: Treated with Dacromet.

Painting of modular expansion joint at IEC workshop for NOH2 project in Doha Qatar, 2018

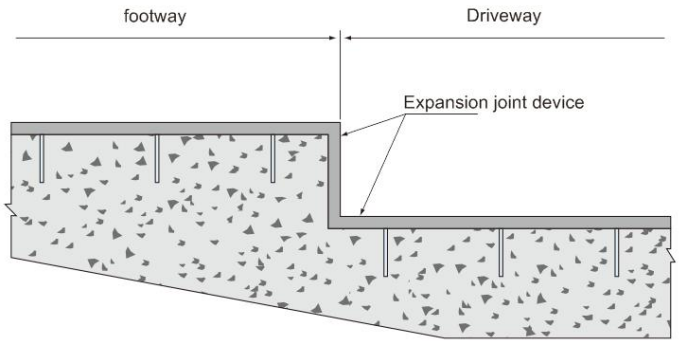
Painting of finger expansion joint at IEC for Tama Bridge over Nile, Egypt, 2019

paint film thickness 243 microns (C5-Ml) for E-ring road project in Doha Qatar, 2018

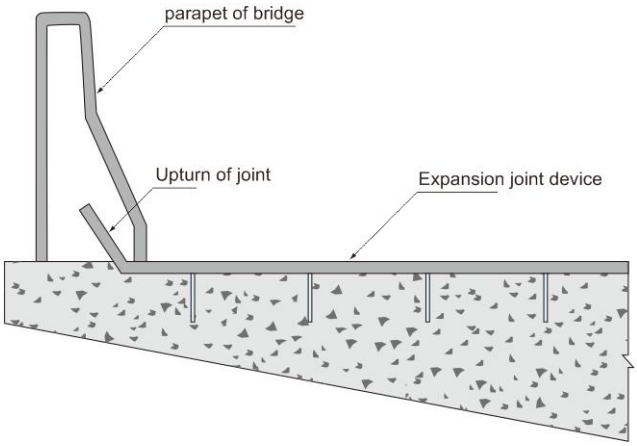
Hot-dip-galvanized treatment for NOH2 project in Doha Qatar, 2018

Sidewalk and parapet design

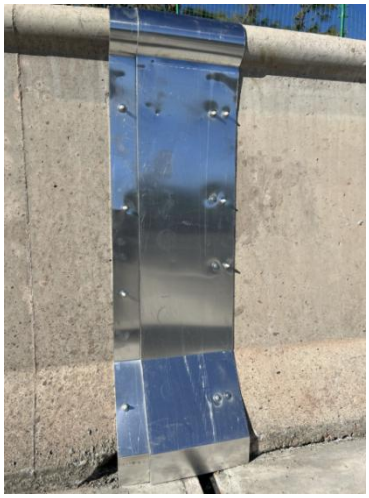
Many joints must be designed to integrate with sidewalks or parapets. For modular joints, an upturn design allows them to extend into parapets or sidewalks.



Upturn design of modular joint so they can extend upward into parapet or sidewalk

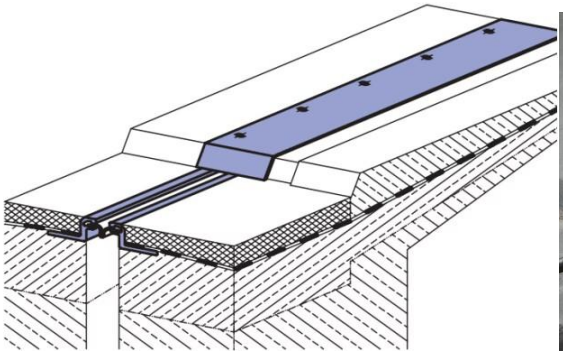


how the upturn extends into the reserved void in the parapet



Cover plate over the modular expansion joint in the parapet area

To ensure a safe passage for pedestrians or cyclists, a thin galvanized steel cover plate is installed over the expansion joint on sidewalks. This plate is bolted on one side, allowing the other side to move freely and accommodate expansion.



A typical design of a cover plate for the sidewalk area over the expansion joint upturn

For detail designs, consult IEC specialist engineer.

Handling, packaging and storage

Bridge expansion joints are protected during transit and storage. Proper lifting methods, including the use of cranes for strip and modular joints and forklifts for finger joints, ensure safety and prevent damage. Joints should be stored in clean, dry environments free from contaminants.

Packed for Irbid Ring, Amman, Jordan, 2016 Packed inside container for Rayyan Road, Qatar, 2020

Packed in closed wooden/steel case or frame for container loading

Applied codes/standards

IEC's expansion joints are designed to meet load requirements as specified by various international standards, including:

- Chinese Specifications
- AASHTO LRFD
- European Standards (ETAG 032)
- Indian Standards (IRC:SP:69-2011)
- BD 33/94 Specifications

IEC's expert engineers are capable of customizing designs to meet unique project specifications.

Installtion&Maintenance

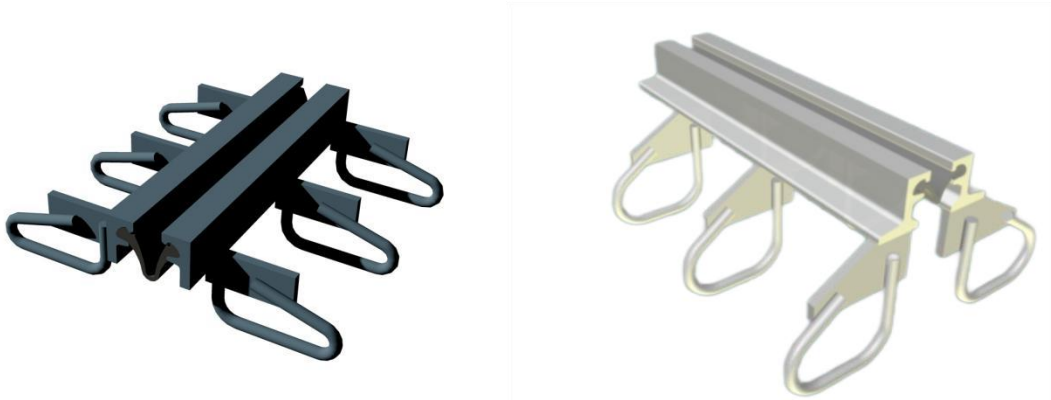
The installation and maintenance processes for various types of expansion joints share some commonalities but also exhibit significant differences. For detailed guidance tailored to your specific needs, consult IEC engineers.

IEC Stripseal Expansion Joint

1. Description

The IEC strip seal expansion joint is a mechanically sealed system that utilizes an extruded elastomeric seal held in place by various steel extrusions, commonly known as edge beams or steel rails. The elastomeric seal, often referred to as a strip seal, is mechanically locked into the steel extrusions to prevent the infiltration of water and debris. The edge beams are anchored to structural elements using high-strength concrete mortar or elastomeric mortar.

This armored joint system is engineered to accommodate movement ranging from 0 mm to 120 mm and can absorb movements and rotations across all three axes without constraint.

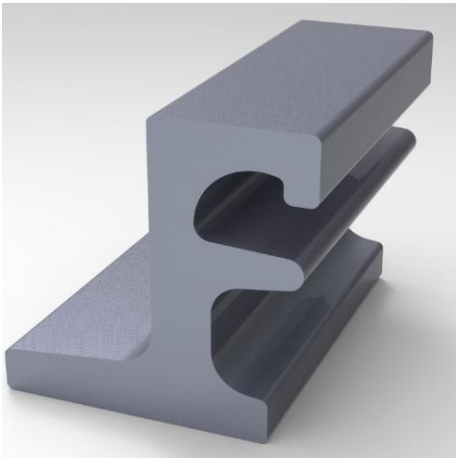


example of a 3-D view of typical type of IEC stripseal expansion joint

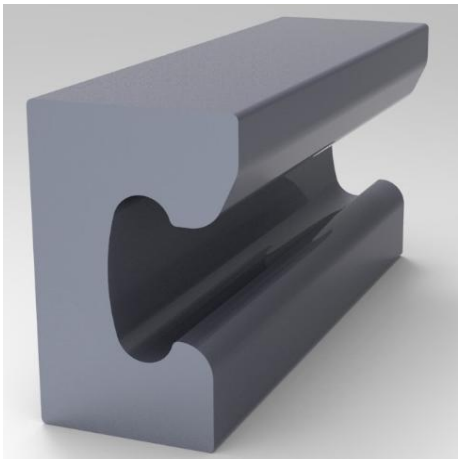
2. Material specifications

2.1 Edgebeam

Edgebeams are manufactured using hot-rolled/machined or hot-rolled/non-machined technology. Edgebeams are of grade of ASTM A709 Grade 50 or S355 or other equivalence grades or higher.



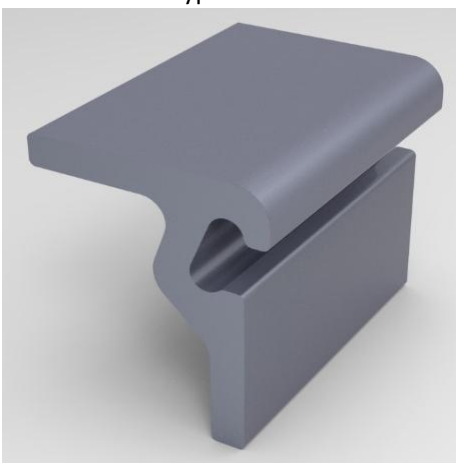
Type Z



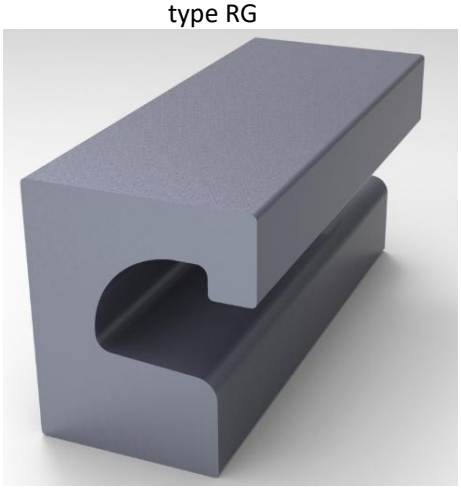
type C

Type F

type RG



Type M



Type C4

Various options of Edgebeams in 3D view (only some shown in here)

2.2 Rubber seal

The elastomeric rubber seal is inserted into the cavity of the edge beams without any mechanical fasteners like screws or bolts. It is designed to maintain watertightness and expel debris during compression. The seal can be easily replaced from the road surface with simple tools.

Manufactured using extrusion and vulcanization technologies, the seal conforms to ASTM D5973-97(2012) standards. IEC primarily offers elastomeric seals made of EPDM, though neoprene options are available upon request, though they are not widely recommended due to cost concerns.

The typical movement range for the strip seal is 80 mm, but with special designs, this can extend up to 120 mm. The seal performs well under temperatures ranging from -40° C to 60° C and is resistant to oil, ozone, aging, and saltwater. A specific lubricant-adhesive is required during installation to ensure a reliable connection between the edge beam cavity and the seal.

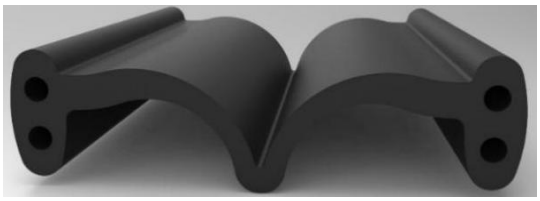
Seal types:

- **Type A seal**

Suitable for edgebeams type E, F, C4 and RG

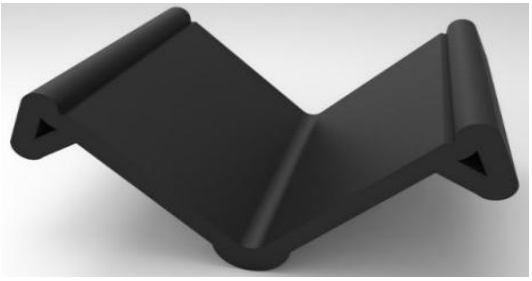
- **Type B seal**

Suitable for edgebeams type C2 or M



- **Type C seal**

Suitable for edgebeams type M



Properties of elastomeric seal

Properties	ASTM specification*	required value
Hardness (Shore A Durometer)	ASTM D2240-04	70±5
Tensile Strength, Min. (MPa)	ASTM D412	15
Elongation at break, Min. (%)	ASTM D412	400
Heat Resistance (aged 70 h@100℃)		
Max. change in hardness	ASTM D573	10
Max. change in tensile strength (%)	ASTM D573	-15
Max. Change in elongation (%)	ASTM D573	-20
Compression set (aged 22 h@100℃) (%)	ASTM D395	20
Ozone resistance (100pphm, 20% strain at 37.7±1℃ 100 h)	ASTM D1149	no crack
Brittleness -40℃	ASTM D746	no failure
Oil Swell 70 h@100℃ Max. Volume change (%)	ASTM D471	-5 ~ +10

*other testing standards are also available and equivalent.

2.3 Anchorage

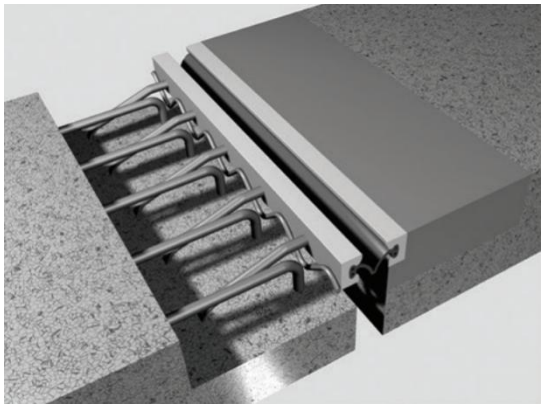
Edge beams are securely connected to the main structure through anchors that are welded directly onto the beams. The loads from vehicular traffic are transferred from the edge beams to the anchors and then to the substructure. These anchors are embedded in high-strength mortar, ensuring maximum resistance to traffic loads.

Anchor types include anchor studs, anchor plates, and anchor loops, or combinations of these,

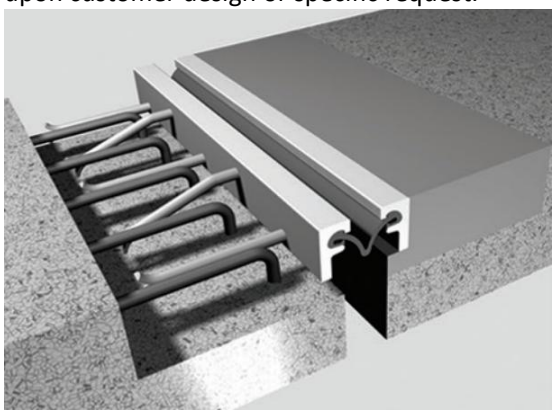
and are generally made of ASTM A709 Grade 36 steel unless specified otherwise. For high-traffic volumes, a combination of anchor plates and anchor loops is often used.

Below are **some examples** of different edgebeams attached to different design of anchorages.

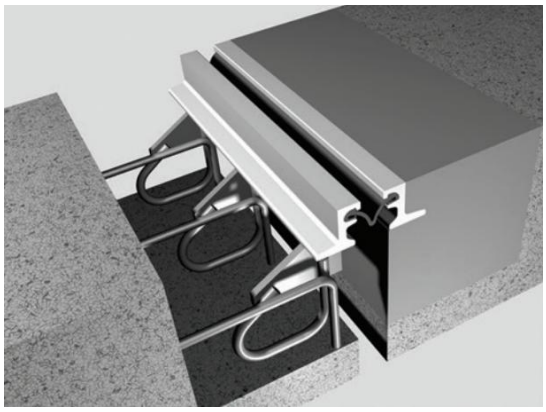
The other anchorage methods are also available upon customer design or specific request.



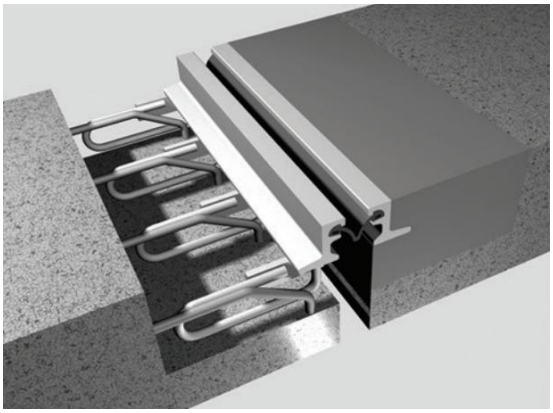
C edgebeam + unheaded studs



F edgebeam + unheaded studs



Z edgebeam + loop anchors (standard)



E edgebeam + anchor loop and plate (shallow)

Selection of different anchorages mainly depends on the design traffic load and limitations of block-out dimensions.

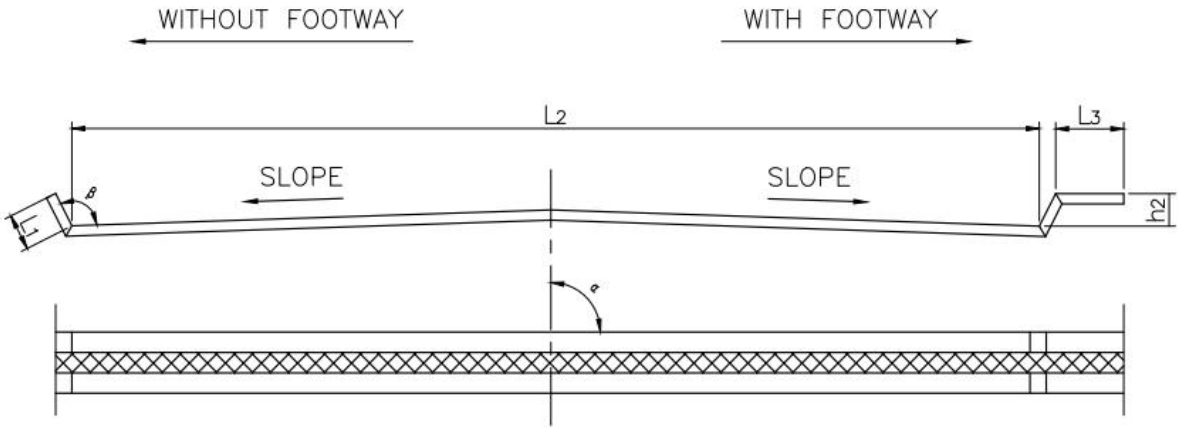
When a skew (angle α) exists between the centerline of the road and the expansion joint, anchor placement must be calculated based on the specific skew angle to ensure proper alignment.

3. Working life and Warranty

The IEC strip seal expansion joint is designed for a service life of 50 years for non-replaceable components such as the edge beams and anchorage, and 25 years for replaceable components like the elastomeric seal.

IEC provides a 10-year warranty for the strip seal expansion joint, provided the joint is correctly installed and maintained. The warranty does not cover damage caused by force majeure events, such as seismic activity or overloading.

4. Required data to fabricate a IEC strip seal expansion joint



Typical necessary information in order to commence production of IEC stripseal expansion joint

L_1 Length of upturn (without footway).
L_2 Net width of bridge deck.
L_3 Width of footway if any.
h_2 Height from carriageway surface to footway surface (with footway).
α Skew angle if any.
β Upturn angle (when not specified, taken at 45°)
Consider the slope in transverse direction if any.

5. Special Design: Type EMR Strip Seal Expansion Joint

The Type EMR (Elastomeric Metal Runner) strip seal is a specialized single-gap joint system. It incorporates a rubber seal between two metal runners, with anchorage using two sinusoidal bars. A unique feature of this system is its use of a rapid-curing elastomeric resin, which bonds directly to the bridge deck without requiring welding, thus eliminating welding fatigue.

The resin has a short curing time of 2 to 3 hours at an installation temperature of 20° C. This makes the EMR system ideal for replacing failed joints while minimizing traffic disruptions, as traffic can resume within hours.

The system can accommodate movement ranges up to 100 mm, providing superior performance in terms of durability and ease of installation.

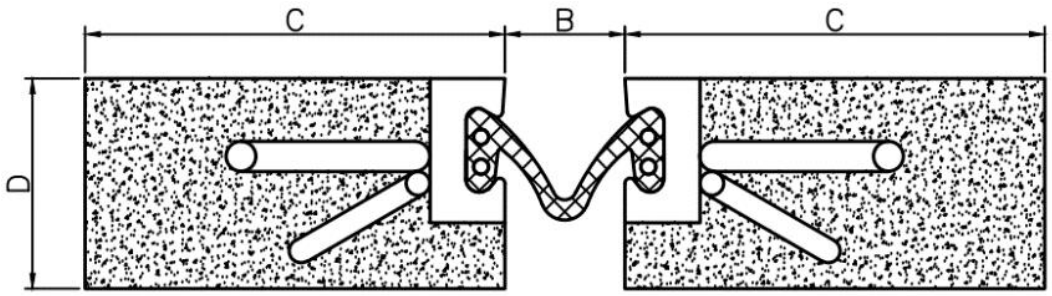
What's the most appealing feature of EMR is its short curing time of resin, which is typically 2~3 hours under 20℃ as installation temperature.

EMR resin specifications

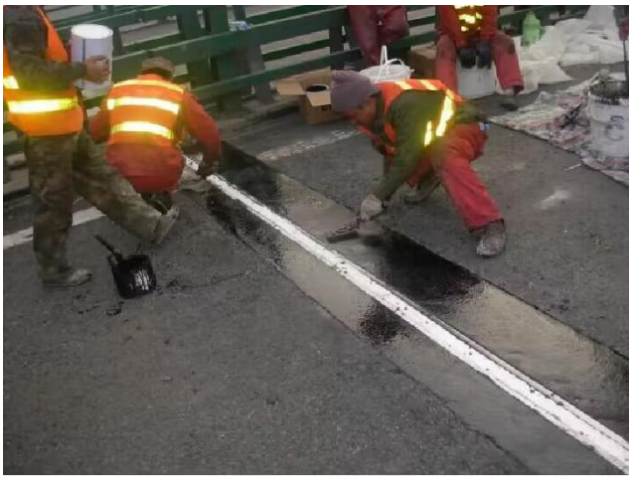
Properties	ASTM test code	Required
Compressive stress	D695	min. 15.16MPa
Rebound@5% deflection	D695	min. 90%
Impact resistance@0℃,-29℃,70℃	D5628	no cracking
Shear strength	N/A	min. 1.72MPa

Consult IEC for approved resin choices

Design detail



Model	Movement capacity	Recess size		Min. gap	Max. gap
		C	D	B_{min}	B_{max}
EMR-35	35	100	60	15	50
EMR-50	50	120	60	15	65
EMR-80	80	140	70	15	95
EMR-100	100	160	70	15	115



- ✓ EMR joint in application and finished EMR joint;
- ✓ Images showing EMR joint supplied&installed by IEC in Bicycle Viaduct in Xiamen, China,2016 (1563meters)
- ✓ IEC has 30+ projects around China up to 2024 using EMR joint
- ✓ Supplied EMR joint rails all over the world for 20+ years

Stainless Steel S304 BEJ expansion joint
(IEC has supplied a number of projects with SS BEJ type expansion joints in Southeast Asia region)

6. Quality Control

Strict and regular quality control processes are employed to ensure the high quality of IEC strip seal expansion joints. Quality checks extend from material procurement to final assembly and are conducted by both suppliers and IEC's in-house quality

control team.

Quality Control Procedures:

1) **Material Identification and Certification**
   QC engineers and fabrication supervisors verify materials against mill certificates and heat numbers (for steel plates, studs, etc.).
2) **Dimensional Checks on Edge Beams**
   Fabrication supervisors conduct dimensional checks on the edge beams, with QC engineers witnessing at least 10% of these checks. Any non-conforming materials are flagged for rejection or replacement.
3) **Fabrication Inspections**
   Fabrication supervisors verify the quantity and placement of anchorages and welding quality. QC engineers witness at least 10% of these tests, ensuring that any disqualifications are addressed before proceeding.
4) **Corrosion Protection Checks**
   A minimum of 10% of dry film thickness checks for corrosion protection are conducted by fabrication supervisors, with QC engineers present for all tests. Non-conforming components are addressed before proceeding.
5) **Final Joint Inspection**
   Dimensional and visual inspections are conducted on all finished joints during the final assembly stage. QC engineers witness a minimum of 10% of these checks, and any issues are rectified.
6) **Packaging Inspection**
   QC engineers inspect packaging according to the packing list, verifying both the quantity and quality of the packaged joints.

7. Suitable applications

IEC Stripseal joints are indeed efficient, cost-effective, and simple in design, making them a popular choice in the bridge expansion joint family. Here are the suitable application areas for stripseal joints:

Stripseal joints are indeed efficient, cost-effective, and simple in design, making them a popular choice in the bridge expansion joint family. Here are the suitable application areas for stripseal joints:

- **Small to Moderate Movement Ranges**

  - Stripseal joints are ideal for accommodating small to moderate movement ranges, typically up to 80 mm. They are well-suited for bridges with limited expansion and contraction due to thermal effects or traffic loads.

- **Highway and Urban Bridges**
  - These joints are frequently used in highway overpasses and urban bridges where traffic loads are consistent, and the movement requirements are minimal to moderate.
- **Pedestrian Bridges**
  - Due to their simple design and ability to provide a smooth, watertight surface, stripseal joints are suitable for pedestrian bridges, ensuring comfort and safety for foot traffic.
- **Railway Bridges**
  - They can also be used in railway bridge applications where limited structural movement is expected, ensuring reliable performance under repetitive dynamic loads.
- **Low- to Medium-Traffic Areas**
  - Stripseal joints are perfect for applications in low- to medium-traffic areas where cost efficiency and durability are important considerations.
- **Bridges in Normal Climate Conditions**
  - Stripseal joints perform well in environments with typical temperature variations. They are less suitable for regions with extreme movements caused by seismic activity or very high thermal variations.
- **Retrofit and Replacement Projects**
  - Their simple design and ease of installation make them a preferred choice for retrofitting older bridges or replacing worn-out joints without extensive downtime.