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ETAG N° 032
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**GUIDELINE FOR EUROPEAN TECHNICAL
APPROVAL**
of
EXPANSION JOINTS FOR ROAD BRIDGES
PART 8: MODULAR EXPANSION JOINTS

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ANNEXES TO THIS ETAG FAMILY PART

Annexes 8-A to 8-L for this family Part correspond to Annexes A – L in Part 1 of this ETAG N° 032, if applicable.

FOREWORD

See Part 1 of this ETAG N° 032.

REFERENCE DOCUMENTS

See Part 1 of this ETAG N° 032.

Additional list of standards referred to in this family Part

| Standards | Clause in this Part of ETAG | Title |
|----------------|--|--|
| EN 1090-2:2008 | Table 8.1 | Execution of steel and aluminium structures – Part 2: Technical requirements for steel structures |
| EN 1337-2 | Table 8.M.2.3, Table 8.M.2.4 | Structural bearings – Part 2: Sliding elements |
| EN 1990 | Table 8.N.1, 8.O.3 | Eurocode: Basis of structural design |
| EN 1991 | 8.O.5, 8.O.7.2 | Eurocode 1: Actions on structures |
| EN 1992 | Table 8.N.1 | Eurocode 2: Design of concrete structures |
| EN 1993-1-8 | Table 8.M.2.1 | Eurocode 3: Design of steel structures – Part 1-8: Design of joints |
| EN 1993-1-9 | Table 8.N.1 | Eurocode 3: Design of steel structures – Part 1-9: Fatigue |
| EN 1999 | Table 8.N.1 | Eurocode 9: Design of aluminium structures |
| EN 10025:2005 | Table 8.M.2.1, Table 8.M.2.3, Table 8.M.2.4 | Hot rolled products of structural steel – All parts |
| EN 10088 | 4.1.7.1.1, Table 8.M.2.1 | Stainless steels – All parts |
| EN 10204 | 8.2.1.1.2, 8.M, Table 8.M.2.1, Table 8.M.2.2, Table 8.M.2.3, Table 8.M.2.4, Table 8.M.2.5 | Metallic products – Types of inspection documents |
| EN ISO 1461 | 4.1.7.1.1, Table 8.M.2.1 | Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods |
| EN ISO 3506 | 4.1.7.1.1, 5.1.7.1.1 | Mechanical properties of corrosion-resistant stainless-steel fasteners |
| EN ISO 3834 | Table 8.1 | Quality requirements for fusion welding of metallic materials |
| EN ISO 12944 | 4.1.7.1.1, 4.1.7.1.2, 5.1.7.1.1, 6.1.7.1.1, Table 8.1 | Paints and varnishes. Corrosion protection of steel structures by protective paint systems – Part 1: General introduction Part 2: Classification of environments Part 3: Design considerations Part 4: Types and surface preparation Part 5: Protective paint systems Part 6: Laboratory performance test methods Part 7: Execution and supervision of paint work Part 8: Development of specifications for new work and maintenance |
| EN ISO 13918 | Table 8.M.2.1, Table 8.N.1 | Welding – Studs and ceramic ferrules for arc stud welding |
| EN ISO 14555 | Table 8.M.2.1 | Welding – Arc stud welding of metallic materials |

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| ISO 34-1:2005 Method A | Table 8.M.2.6a-b, Table 8.M.2.7a-b | Rubber, vulcanized or thermoplastic – Determination of tear strength – Part 1: Trouser, angle and crescent test pieces |
| ISO 37 | Table 8.M.2.6a-b, Table 8.M.2.7a-b | Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties |
| ISO 48 (2005) | Table 8.M.2.6a-b, Table 8.M.2.7a-b | Rubber, vulcanized or thermoplastic – Determination of hardness (Hardness between 10 IRHD and 100 IRHD) |
| ISO 179 | Table 8.M.2.9a-b | Plastics. Determination of Charpy impact strength – Part 1: Non-instrumented impact test Part 2: Instrumented impact test |
| ISO 188 | Table 8.M.2.6a-b, Table 8.M.2.7a-b. | Rubber, vulcanized or thermoplastic – Accelerated ageing and heat resistance tests |
| ISO 527 | Table 8.M.2.8a-b, Table 8.M.2.9a-b | Plastics. Determination of tensile properties – Part 1: General principles Part 2: Test conditions for moulding and extrusion plastics |
| ISO 604 | Table 8.M.2.9a-b | Plastics – Determination of compressive properties |
| ISO 812 | 5.1.7.2, Table 8.M.2.6a-b, Table 8.M.2.7a, Table 8.M.2.9a | Rubber, vulcanized or thermoplastic – Determination of low-temperature brittleness |
| ISO 813 | Table 8.M.2.7a | Rubber, vulcanized or thermoplastic – Determination of adhesion to a rigid substrate. 90 degrees peel method |
| ISO 815 | Table 8.M.2.6a-b, Table 8.M.2.7a-b, Table 8.M.2.9a-b | Rubber, vulcanized or thermoplastic – Determination of compression set at ambient, elevated or low temperatures |
| ISO 899-1 | Table 8.M.2.9a-b | Plastics – Determination of creep behaviour – Part 1: Tensile creep |
| ISO 1183 | Table 8.M.2.8a-b, Table 8.M.2.9a-b | Plastics. Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pycnometer method and titration method |
| ISO 1431-1 | Table 8.M.2.6a, Table 8.M.2.7a-b, Table 8.M.2.9a | Rubber, vulcanized or thermoplastic – Resistance to ozone cracking – Part 1: Static and dynamic strain testing |
| ISO 1817 | Table 8.M.2.6a | Rubber, vulcanized – Determination of the effect of liquids |
| ISO 1827 | Table 8.M.2.7a-b, Table 8.M.9a-b | Rubber, vulcanized or thermoplastic – Determination of shear modulus and adhesion to rigid plates – Quadruple-shear methods |
| ISO 2039-1 | Table 8.M.2.8a-b, Table 8.M.2.9a-b | Plastics – Determination of hardness – Part 1: Ball indentation method |
| ISO 2081 (2004) | 4.1.7.1.1, Table 8.M.2.1 | Metallic and other inorganic coatings – Electroplated coatings of zinc with supplementary treatments on iron or steel |
| ISO 2578 | Table 8.M.2.9a | Plastics – Determination of time-temperature limits after prolonged exposure to heat |
| ISO 2781 (2004) Technical corrections 1 1996 | Table 8.M.2.6a-b, Table 8.M.2.7a-b | Rubber, vulcanized – Determination of density. Technical corrigendum 1 to standard ISO 2781:1988 |
| ISO 3522 | 4.1.7.1.1 | Cast aluminium alloys – Chemical composition and mechanical properties |
| ISO 7619-2 (2006) | Table 8.M.2.6a-b, Table 8.M.2.7a-b | Rubber, vulcanized or thermoplastic – Determination of indentation hardness – Part 2: IRHD pocket meter method |

Note: Some of these standards are also referred to in Part 1.

Section one: INTRODUCTION

1. PRELIMINARIES

1.1 LEGAL BASIS

See Part 1 of this ETAG N° 032.

1.2 STATUS OF ETAG

See Part 1 of this ETAG N° 032.

This document shall be used in conjunction with ETAG N° 032, Expansion joints for road bridges Part 1. If the text in Part 1 applies to this family of products then reference will be made to the appropriate clause in Part 1 ("See Part 1 of this ETAG N° 032").

2. SCOPE

2.1 SCOPE AND DEFINITION

2.1.1 General

This Part of ETAG 032 specifies the product performance characteristics, methods of verification and assessment procedures to ensure the intended use of Modular Expansion Joints for road bridges.

This Guideline covers the expansion joints for road bridges used to ensure the continuity of the running surface as well as bearing capacity and the movement of the bridges whatever the nature of the material of the bridge structure (concrete, steel, ...).

The products are designed, manufactured and installed in accordance with the ETA holder's design and installation guide.

Expansion joints for moveable bridges are not covered by this Guideline.

2.1.2 Definitions

The following explanation details the general definition given in 2.1.2.2 of Part 1 of this ETAG 032.

The modular joints consist in the traffic direction of a succession of watertight elements (seal) comprising movement controlled metal beams (centre beams), supported by moveable substructures bridging the structural gap i.e. cross beams, cantilevers or pantographs. The metal beams are flush with the running surface. The assembly of watertight elements, centre beams and substructures is situated between edge beams, rigidly and in a watertight manner connected to the main structure. The top surfaces of the centre beams and edge beams are flush with the running surface. Where seals are flush with the running surface, they are not designed to carry the traffic loads.

Examples of moveable substructures are:

- Centre beams fixed to the crossbeams,
- Centre beams sliding on the crossbeams,
- Centre beams supported by a pantograph structure.

Examples of control systems are:

- Elastomeric springs,
- Pantograph systems,
- Specially designed watertight elements,
- System guided by kinematic conditions (swivel).

Examples of seal elements:

- V-shape strip seals,
- Box seals.

Combinations of these systems may occur.

Annex 8.P shows typical cross sections and plan views of Modular Expansion Joints.

2.1.3 Relationship with European harmonised standards

According to Part 1 of this ETAG N° 032: not relevant.

2.2 USE CATEGORIES AND KITS

2.2.1 Use categories

See Part 1 of this ETAG N° 032.

2.2.2 Kits

See Part 1 of this ETAG N° 032.

The modular expansion joint is component based. The components to be assessed are listed in Annex 8.M (8.M.1.2) and Annex 8.N.

Note: An additional top layer (e.g. epoxy layer with quartz or corundum and purified iron or slag) can be used to achieve a higher level of skid resistance. This is not considered to be part of the kit and any enhanced skid resistance is not declared with the CE marking.

The modular joint can be equipped with optional elements for noise reduction. The noise reduction effect is not part of the ETAG. The noise reducing elements are treated as structural components only.

Note: The modular expansion joint is normally completely assembled in the factory and transported to the construction site for installation. When needed, additional features such as cover plates are added on site.

For transportation purposes or installation procedures affected by traffic measures (e.g. lane by lane) it may be necessary to install the joint in several sections, which are connected on site.

2.3 ASSUMPTIONS

See Part 1 of this ETAG N° 032.

2.3.1 Main structure

See Part 1 of this ETAG N° 032.

2.3.2 Temperatures

See Part 1 of this ETAG N° 032.

All ranges of operating temperatures according to ETAG 032, Part 1, 2.3.2, apply.

To demonstrate that materials are fit for the use over the temperature range chosen by the manufacturer, appropriate test(s)/verification (i.e. brittleness test for rubber at low temperature, related energy absorption capacity in case of steel elements, appropriate alloy for steel and aluminium at low temperature, compatibility of linear expansion coefficients of bonded elements) shall be made.

2.3.3 Installation

See Part 1 of this ETAG N° 032 and Chapter 7 of this Part.

2.3.4 Working life

See Part 1 of this ETAG N° 032.

All categories according to ETAG N° 032, Part 1, 2.3.4, apply.

The working life of the kit is limited by the concerned working life of the non-replaceable components.

For components the following applies:

| Category | | Assumed working life |
|----------|--|---|
| A | Non-replaceable | Equal to the assumed working life of the kit |
| B | Replaceable with major obstruction of the traffic flow | At least 0,5 time the assumed working life of the kit, but not less than 10 years |
| C | Replaceable with minor obstruction of the traffic flow | Not less than 10 years |

For explanation and further detailing, see Annex 8.M.

Note: The possibility of a working life evaluation might not be achievable for every component, i.e. elements subjected to wear from bridge movements under traffic loads.

The assumed working life of the replaceable components shall be stated in the ETA.

3. TERMINOLOGY

3.1 COMMON TERMINOLOGY AND ABBREVIATIONS

See Annex A of Part 1 of this ETAG N° 032.

3.2 TERMINOLOGY AND ABBREVIATIONS SPECIFIC TO THIS ETAG

3.2.1 Terminology

See Part 1 of this ETAG N° 032.

For additional terms and definitions specific for this family Part, see the following table.

| | |
|--------------------------|---|
| Bearing | Element transferring the (traffic and prestress) loads from the centre beam to the crossbeam and/or to the main structure. |
| Centre beam | Approximately equidistant (in relation to the governing bridge deck gap) guided movement controlled beam providing a road surface with adequate traffic bearing resistance and supported by crossbeams, pantographs etc. (also called "lamella"). |
| Control element | Element ensuring that the centre beams are at approximately equal distances at the various opening positions of the modular joints. |
| Crossbeam | Beam supporting the centre beams and supported by one part of the bridge and the abutment and/or another part of the bridge respectively (also called "traverse"). |
| Edge beam | The steel nosing of the main structures adjacent to the joint. |
| Joist box, crossbeam box | A steel box embedded in the main structure, which supports the crossbeam. |
| Lazy tong (pantograph) | The lazy tong or pantograph support acts as a crossbeam with a variable length by rotation of its parts. |
| Prestress element | A prestress element prevents uplift of the centre beam to crossbeam connection and/or uplift in the crossbeam to main structure connection. |

Further explanation of these terms and definitions is given in Annex 8.P.

3.2.2 Abbreviations

See Part 1 of this ETAG N° 032.

No specific abbreviation for this Part.

Section two: GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

GENERAL NOTES

See Part 1 of this ETAG N° 032.

4. REQUIREMENTS

For the works and their relationship to the Road Bridge Expansion Joint characteristics

See Part 1 of this ETAG N° 032.

4.0 TABLE LINKING THE ESSENTIAL REQUIREMENTS TO PRODUCT PERFORMANCE

Comprehensive table

See the comprehensive Table in Part 1 of this ETAG N° 032 but the clauses in the last column of this table refer to this Part of this ETAG.

4.1 KITS

The resistance and stability of the kit are governed by the resistance and stability of the components and how they are incorporated into the expansion joint and the design of the assembly.

4.1.1 Mechanical resistance and stability

4.1.1.1 General

See Part 1 of this ETAG N° 032.

The requirements for mechanical resistance (static behaviour) of Table 4.1.1 of ETAG 032, Part 1, are detailed in Annex 8.N.

The skew angle between the traffic direction and the longitudinal axis of the joint influences the load transfer and shall be considered.

4.1.1.2 Mechanical resistance

4.1.1.2.1 General

For the requirements, see 4.1.1.1.

In addition:

The support of the pavement by the joist boxes and other plate elements acting as a steel deck shall have sufficient stiffness to prevent damage to the pavement. This is achieved when the deflection under SLS loads does not exceed $0,0025 \times l$ or $0,0025 \times b$, where l and b are the spans for simply supported plates and $0,005 \times l$, where l is the length of the cantilevering part.

For rectangular plates supported by four edges, the smallest value for b and l applies; for plates supported by three edges, the smaller value for the simple span or the cantilever applies.

The vertical deflection of load carrying elements due to characteristic traffic loads, in accordance with Part 1, Annex G equation [G.14], shall not be greater than 5 mm.

4.1.1.2.2 Actions

See Part 1 of this ETAG N° 032.

4.1.1.3 Resistance to fatigue

4.1.1.3.1 General

See Part 1 of this ETAG N° 032.

For the requirements, see 4.1.1.1.

4.1.1.3.2 Actions for fatigue assessment

See Part 1 of this ETAG N° 032.

4.1.1.4 Seismic behaviour

See Part 1 of this ETAG N° 032.

All approaches of Part 1 apply.

4.1.1.5. Movement capacity

See Part 1 of this ETAG N° 032.

The influence of displacement velocity and the temperature is not relevant for this family product.

Permanent relative rotation angle $\tilde{\epsilon}_{r_p}$

Where the bearings of a sloped main structure move in the horizontal plane, the slope of the expansion joint in the traffic direction $\tilde{\epsilon}_{\alpha_p}$ can deviate from the slope of the running surface of the main structure.

The manufacturer shall declare the α_p value. This value shall not be less than 2 %.

Accidental relative rotation angle $\tilde{\epsilon}_{r_a}$ (for maintenance purposes)

A relative deviation of the slope in the traffic direction $\pm \alpha_a$ shall be verified for short term movement conditions. This value shall be declared for the accidental design situation/combination [G.9] given in Annex G of Part 1.

Cyclic relative rotation angle $\tilde{\epsilon}_{r_f}$

A rotation angle $\pm \alpha_f$ shall be declared for cyclic rotations.

4.1.1.6 Cleanability

See Part 1 of this ETAG N° 032.

4.1.1.7 Resistance to wear

For principles, see Part 1 of this ETAG N° 032.

Components subject to wear shall have working life category A, B or C (see 2.3.4) and they shall be accessible for inspection (including measurement) and replacement.

The accumulation of wear of the sliding surfaces during the declared working life shall not result in one or more of the conditions mentioned below:

- Insufficient mechanical resistance to meet the requirements of 4.1.1.1,
- Change in kinematic conditions (e.g. loss of original contact pressure in the sliding surface and with respect to the planned load transfer in the joint in particular with respect to uplift forces),
- Complete vanishing of the sliding material and/or the counter material,
- Increase of friction to a degree which causes damage to the expansion joint with respect to imposed movements.

This means that, in relation to temperature effects in the bridge, the total slide path for the test procedure according to 5.1.1.7 of this ETAG Part, in relation to a working life of "a" years of a component is derived from $[a] \times 365 \times 0,33 \times$ maximum movement capacity of the expansion joint = $120 \times [a]$ cycles with maximum movement capacity of the joint (a = number of years).

4.1.1.8 Watertightness

See Part 1 of this ETAG N° 032.

The centre beams, edge beams and seals ensure the watertightness of a modular joint.

The featuring of the edge, centre beams and seal elements adapted to the cross section of the bridge shall prevent water from circulating to the underside of the seal element at the lower end. The joint shall be designed to minimize the capillary action.

The design shall not be susceptible to excessive tensioning (pull out) of a seal element caused by traffic loads and imposed movements.

Requirements for materials are given in Annex 8.M.

4.1.2 Safety in case of fire

According to Part 1 of this ETAG 032: not relevant.

4.1.3 Hygiene, health and environment

See Part 1 of this ETAG N° 032.

4.1.4 Safety in use

4.1.4.1 Ability to bridge gaps and levels in the running surface

4.1.4.1.1 Allowable surface gaps and voids

See Part 1 of this ETAG N° 032.

4.1.4.1.2 Level differences in the running surface

See Part 1 of this ETAG N° 032.

4.1.4.2 Skid resistance

See Part 1 of this ETAG N° 032.

Any surface elements with closed surfaces larger than 150 x 150 mm shall fulfil the requirements of ETAG 032, Part 1.

4.1.4.3 Drainage capacity

See Part 1 of this ETAG N° 032.

Note: Modular joints are watertight and, due to the surface geometry of edge beams, centre beams and seals, standing water on the running surface does not occur.

4.1.5 Protection against noise

According to Part 1 of this ETAG N° 032: not relevant.

4.1.6 Energy economy and heat retention

According to Part 1 of this ETAG N° 032: not relevant.

4.1.7 Aspects of durability, serviceability and identification of the products

See Part 1 of this ETAG N° 032.

4.1.7.1 Aspects of durability

4.1.7.1.1 Corrosion

Unless intrinsically corrosion resistant, metallic components are considered to be affected by corrosion and all metallic surfaces have to be protected.

See Part 1 of this ETAG N° 032 and in addition:

The corrosivity category C4, C5-I or C5-M shall be declared in accordance with EN ISO 12944-2 in relation to the durability expectancy "high" in accordance with EN ISO 12944-5.

Only systems (including layer thicknesses) given in EN ISO 12944-5 shall be used.

Surfaces that will be in contact with concrete shall receive no coating. At the transitions between cast-in surfaces and surfaces exposed to the weathering conditions, 50 mm of overlap of the full corrosion protection system into the cast-in surfaces shall be provided.

The ETA may state that the wear of the coating of the trafficked surfaces is a normal phenomenon for which no additional measures have to be taken.

If high strength friction grip bolts are used, they shall have zinc-plated coating Fe/Zn 25. This shall be in accordance with ISO 2081 applied in accordance with EN ISO 1461. Contact surfaces of steel plates and splices in "High Strength Friction Grip Bolt Connections" shall have a corrosion protection of only one layer ethyl silicate zinc compound, 40 µm thick on a SA 3 sand blasted surface with a minimum roughness Rz = 60 µm in accordance with EN ISO 12944-4.

Stainless steels in accordance with EN 10088 shall be: Grades 1.4401, 1.4404 or 1.4571 (see also Annex 8.M) or with higher corrosion resistance.

Stainless steel bolts shall be in accordance with EN ISO 3506, with grades 1.4401, 1.4404, 1.4571 or equivalent.

Aluminium alloys shall at least have a corrosion resistance of category "B" in accordance with ISO 3522, Table C.1.

Sliding surfaces made of austenitic steel shall not have a corrosion protection system.

4.1.7.1.2 Chemicals

- Metallic components

See Part 1 of this ETAG N° 032. For protection against chemicals, the climate classifications C4, C5-I and C5-M of EN ISO 12944-2, and the durability expectancy in accordance with EN ISO 12944-5, shall be taken into account.

- Rubber components

See Annex 8.M.

- Seals

See Annex 8.M.

- Bearings, prestress and control elements

See Annex 8.M.

- Plastic components

See Annex 8.M.

4.1.7.1.3 Ageing resulting from temperature, UV-radiation and ozone

See Annex 8.M.

4.1.7.1.4 Resistance against freeze – thaw

Not relevant.

4.1.7.2 Aspects of serviceability

See Part 1 of this ETAG N° 032.

4.1.7.3 Aspects of identification

See Part 1 of this ETAG N° 032.

Each modular expansion joint shall be clearly identified in order to fulfil the traceability requirements, e.g. with a label, comprising the following information:

- Manufacturer's name and address,
- Type of product,
- Batch number,
- Date of manufacture.

4.2 COMPONENTS

See Part 1 of this ETAG N° 032.

The manufacturer shall present a list of components with the material characteristics (including tolerances) as given in Annexes 8-M in this family Part. Testing shall be carried out to demonstrate that the component meets the declared characteristics.

Components shall be defined and specified in the Technical Manual according to their function and their role in the product. This shall include their characteristics, method of handling and their source of supply.

The tests determine the material characteristics and performance.

The Approval Body shall identify the characteristics of the components of a Modular Expansion Joint which have to be verified during the approval procedure in accordance with this Part of the ETA Guideline.

For functions and requirements for components and materials, see Annex 8.M, which gives the details for commonly used components and materials.

For components and materials not covered in Annex 8.M, the equivalent level of required performance shall be established.

5. METHODS OF VERIFICATION

See Part 1 of this ETAG N° 032.

5.0 GENERAL

Comprehensive table

See Table in Part 1 of this ETAG N° 032 but the clauses in the last column in the table refer to this Part of the ETAG.

5.1 KITS

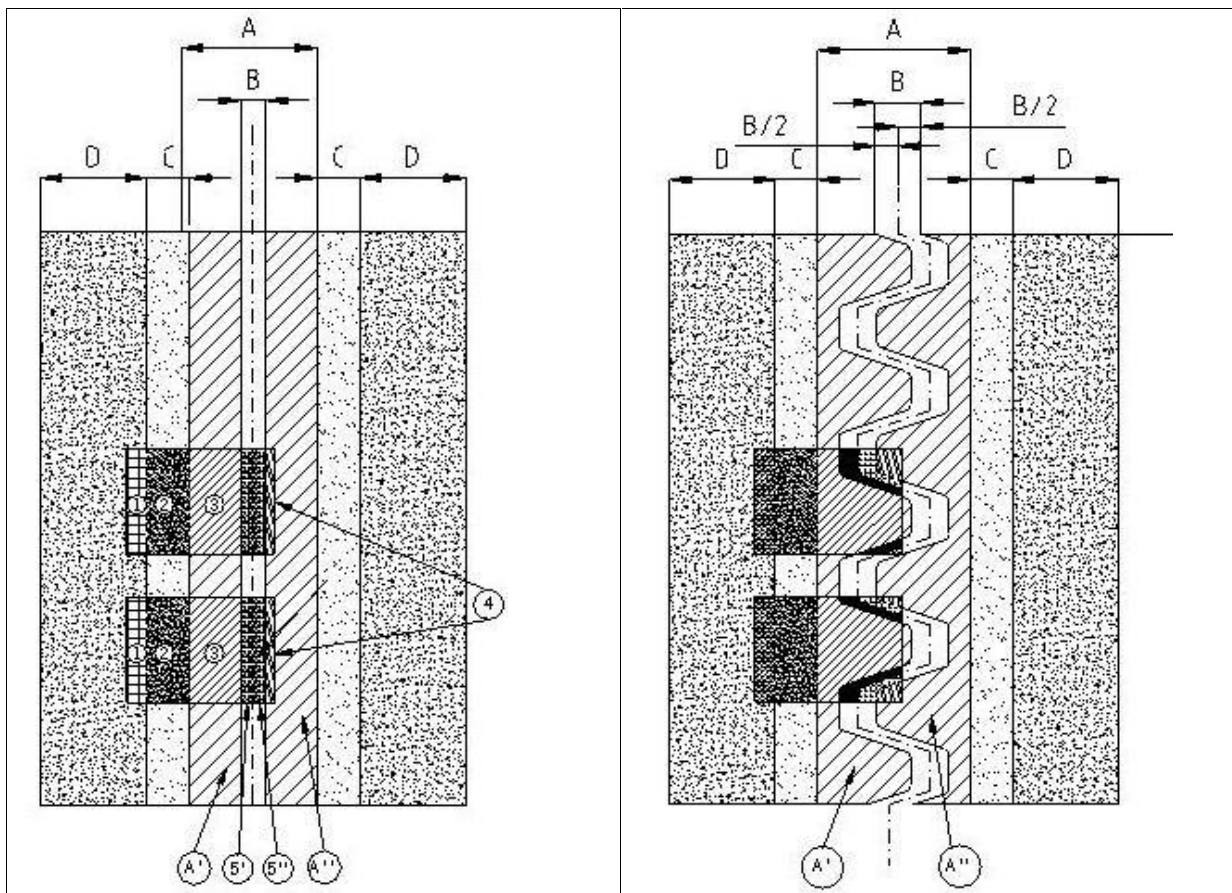
5.1.1 Mechanical resistance and stability

5.1.1.1 General

See Part 1 of this ETAG N° 032.

The actions, loads and combinations of loads and opening positions to be used for verification are given in Annex G of ETAG 032, Part 1.

The following load distribution applies: In case the gaps are designed straight-oriented, the load distribution as given in the right-hand sketch in Figure 5.1.1.1 applies. In case of non-straight-oriented gaps, the load distribution as given in the left-hand sketch in Figure 5.1.1.1 applies. The conditions for load distribution, detailed for other product families, are to be considered.



For Key, see Figure G1 in Part 1

Figure 5.1.1.1: Load distribution for Modular expansion joints

Where a sloped main structure has bearings which are moving in the horizontal plane, the slope of the expansion joint may deviate from the slope of the running surface of the main structure. The maximum slope occurring on the expansion joint surface shall be considered for verification.

5.1.1.2 Mechanical resistance

Modular Expansion Joints shall be calculated using common engineering principles (see also Annex 8.N). The calculation procedures shall be calibrated with dynamic field measurements (see Annex 8.O).

5.1.1.2.1 Calculations

The load distribution and transfer shall be analysed, including the dynamic response effects for the kinematic conditions and the appropriate support conditions. Where internal spring systems play a role in the load transfer, proper analysis of their influence shall be made. Unevenness between the surface elements (centre beams, edge beams) of the joint shall be considered. Attention shall be paid to the effect of ageing on the damping.

The influence of the traffic direction on the load transfer shall be considered for the declared maximum angle.

The (quasi) static assessment is described in Annex 8.N.

In addition:

The support of the pavement by the joist boxes and other plate elements acting as a steel deck shall be verified for the deflection under SLS loads.

5.1.1.2.2 Testing

The dynamic amplification factors for vertical and horizontal loads (vertical- horizontal transfer factors, including dynamic effects) shall be derived from analyses calibrated with field-testing (see Annex 8.O).

In conjunction with Annex 8.0, § 8.0.3, other joints than the tested type are considered included in the approval by means of relevant additional calculations.

The above determined characteristics apply for joints of the same type, but with other dimensions, provided the vertical, horizontal and rotational natural frequencies for the respective parts or components do not fall below 90 % of those of the originally tested and analysed specimen.

Note: When the natural frequencies are higher, the dynamic response will be smaller than that of the tested joint and the tested values can be used as a safe assumption.

For elastomeric and plastic, or hybrid, components, testing on full scale components shall show at least: Spring stiffness, Deformations, Relaxation, Creep, Tear resistance and Load bearing capacity. Connections between components not covered by standards shall be tested for their resistance and deformation behaviour.

- Metal components

Testing of full scale parts of components or full scale part of components shall be performed in accordance with the procedures given in Annex 8.M.

- Non metallic or composite components

Specific testing methods shall be developed taking into account the function of the component and the materials selected. Attention shall be paid to the susceptibility to stress reversals, tear strength, the effect of prestress, relaxation and ageing. The test methods for materials and full-scale components are described in Annex 8.M.

5.1.1.3 Resistance to fatigue

The fatigue resistance is based on test results, calculations and/or combinations of them.

The dynamic aspects (dynamic amplification factors, upswing and damping) for vertical and horizontal loads shall be derived from analyses calibrated with field-testing (see Annex 8.O).

The fatigue verification of the components shall be carried out with the guidance given in Annexes 8.M and 8.N.

The verification of the resistance to fatigue of the expansion joint shall include the anchorage system as a composite acting structure, being a part of the kit.

If, due to the damping characteristics of the joint the stress intervals of the cycles after the initial cycle are smaller than 30 % of the stress intervals of the initial cycle, these intervals do not need to be considered for a fatigue assessment.

Special attention shall be paid to the fatigue consequences of the dynamic response of the non-loaded parts due to the traffic loads (e.g. cantilevers with low damping at free vibration).

5.1.1.4 Seismic behaviour

See Part 1 of this ETAG N° 032.

The intrinsic movement capacities of a modular joint may not allow movements in all directions. In this case, the result of the evaluation procedure shall indicate which measures, not necessarily included in the joint itself, shall be taken in order to ensure a proper response to seismic events.

5.1.1.5 Movement capacity

See Part 1 of this ETAG N° 032.

In addition to the nominal movement capacity, derived by testing, the movement capacity shall also be verified by means of analysis of kinematic behaviour, in relation to the skew and guide angle for combinations of longitudinal movement, transverse movements perpendicular to the main direction of the superstructure, relative vertical movements between the main structures and rotations of and between components.

These values shall be verified, including the influence of longitudinal slopes.

Permanent relative rotation angle α_p

This value has to be derived from the geometry of the joint design and the characteristics of the components. This value α_p shall be declared.

Accidental relative rotation angle α_a

This value has to be derived from the geometry of the joint design and the characteristics of the components to be used in conjunction with the design situation given in combinations [G.9]. This value α_a shall be declared.

Cyclic relative rotation angle α_f

This value has to be derived from the geometry of the joint design and the characteristics of the components to be used in conjunction with the design situation given in combinations [G.13]. This value $\pm \alpha_f$ shall be declared.

5.1.1.6 Cleanability

See Part 1 of this ETAG N° 032.

5.1.1.7 Resistance to wear

The testing procedure is given in Annex 8.M, Section 4.

The working life with respect to wear of a component shall be determined assuming that on average each day results in a movement of the expansion joint equal to 33 % of the maximum movement capacity.

- Conditions:

Sliding elements with materials susceptible to wear and in addition: ageing, temperature, debris etc. shall be tested in aged conditions under adapted temperatures, where relevant.

- Measurements:

The following aspects shall be measured and reported:

- Friction coefficients, static and dynamic,
- Abrasion,
- Thickness reduction.

A visual inspection of the sliding surfaces shall be carried out and reported.

5.1.1.8 Watertightness

See Part 1 of this ETAG N° 032.

For the test method according to L.5.3 of Annex L in Part 1, the worst condition is defined by the maximum offset between two adjacent centre beams and imposed deformations at bends (i.e. at kerb units) and restrained deformations due to foreign objects (i.e. stones).

In addition to the conditions described before and deviating from ETAG 032, Part 1 Annex L, the following shall be considered:

- Use aged elastomeric materials as described in Annex 8.M, Table 8.M.2.6a (Exposure: 7 days hot air at 70 °C),
- Opening position with most adverse effects (longitudinal, transverse) on the seal fixings.

5.1.2 Safety in case of fire

According to Part 1 of this ETAG 032: not relevant.

5.1.3 Hygiene, health and environment

See Part 1 of this ETAG N° 032.

5.1.4 Safety in use

5.1.4.1 Ability to bridge gaps and levels in the running surface

5.1.4.1.1 Allowable surface gaps and voids

See Part 1 of this ETAG N° 032.

5.1.4.1.2 Level differences in the running surface

See Part 1 of this ETAG N° 032.

Verification shall be carried out by analysis of the technical file and drawings of the expansion joint. The vertical deflections of the joint, due to loads associated with the SLS, shall be calculated.

5.1.4.2 Skid resistance

See Part 1 of this ETAG N° 032.

5.1.4.3 Drainage capacity

See Part 1 of this ETAG N° 032.

5.1.5 Protection against noise

According to Part 1 this ETAG N° 032: not relevant.

5.1.6 Energy economy and heat retention

According to Part 1 of this ETAG N° 032: not relevant.

5.1.7 Aspects of durability, serviceability and identification of the products

See Part 1 of this ETAG N° 032.

5.1.7.1 Aspects of durability

5.1.7.1.1 Corrosion

For intrinsically corrosion resistant materials i.e. stainless steels and aluminium alloys the following applies: The selected material shall be compared to the required types in 4.1.7.1.1.

See also Annex 8.M.

For other materials an assessment procedure in accordance with EN ISO 12944 shall be carried out. It shall be verified that the declared corrosivity category (C4, C5-I or C5-M) in accordance with EN ISO 12944-2 has been used and the durability expectancy in accordance with EN ISO 12944-5 will be achieved.

It shall be verified that surfaces that will be in contact with concrete receive no coating and that the transitions between cast-in surfaces and surfaces exposed to the weathering conditions have 50 mm of overlap of the full corrosion protection system into the cast-in surfaces.

5.1.7.1.2 Chemicals

- Metallic components

Covered by 5.1.7.1.1.

- Rubber components

See Annex 8.M.1.

- Plastic components

Not relevant.

5.1.7.1.3 Ageing resulting from temperature, UV-radiation and ozone

See Annex 8.M.1.

5.1.7.1.4 Resistance against freeze – thaw

Not relevant.

5.1.7.2 Aspects of serviceability

See Part 1 of this ETAG N° 032.

Verification of the accessibility and replaceability of the components shall be carried out based on the technical documentation of the expansion joint.

With respect to the operating temperature condition, according to 2.3.2, for the execution of the brittleness test (ISO 812) the following temperatures apply:

- -25 °C for operating temperatures down to -20 °C,
- -40 °C for operating temperature equal to -30 °C,
- -55 °C for operating temperature equal to -40 °C.

5.1.7.3 Aspects of identification

See Part 1 of this ETAG N° 032.

5.2 COMPONENTS

See Part 1 of this ETAG N° 032.

The manufacturer shall present a list of components with test methods and/or standards.

The tables in Annex 8.M give requirements and assessment methods which shall be used where they are applicable. Where the methods do not apply or do not assess the correct characteristics for that component/material, alternative assessment methods, based in preference on European or ISO standards, shall be used by agreement between the ETA applicant and the Approval Body.

Without further testing all components made of the materials defined in the tables of Annex 8.M, are deemed to perform well at operating temperatures between -25 °C and +45 °C. The influence of the temperatures beyond the values of -25 °C and +45 °C shall be demonstrated by appropriate test(s)/verification (i.e. Brittleness test for rubber at low temperature; related energy absorption capacity in case of steel elements, appropriate steel or aluminium alloy for low temperature, compatibility of linear expansion coefficients of bonded elements).

6. ASSESSING AND JUDGING THE FITNESS OF PRODUCTS FOR AN INTENDED USE

This chapter details the performance requirements to be met (Chapter 4) in precise and measurable (as far as possible and proportional to the importance of the risk) or qualitative terms, related to the product and its intended use, using the outcome of the verification methods (Chapter 5).

6.0 TABLE LINKING THE ESSENTIAL REQUIREMENTS TO PRODUCT REQUIREMENTS

| ER | Characteristics specified in the mandate | ETAG paragraph on product performance to be assessed | Class, use category, criterion | | No performance determined option | |
|--------------------|--|--|--|----------------------------|----------------------------------|-----|
| 1 | Mechanical resistance | 6.1.1.2 | Carriageway | Pass/Fail | No | |
| | | | And/or footpath | Pass/Fail | No | |
| | | | And/or options: - Accidental load on footpath | Pass/Fail | No | |
| | | | - Collision on kerb | Pass/Fail | No | |
| | Resistance to fatigue | 6.1.1.3 | Pass/Fail | | No | |
| | Seismic behaviour | 6.1.1.4 | Declaration of selected approach and relevant information (aspects, etc.) | | Yes | |
| | Movement capacity | 6.1.1.5 | Declared values with reaction forces | | No | |
| | | | Minimum clearances | | Yes | |
| | | | Maximum skewness | | Yes | |
| Cleanability | 6.1.1.6 | Pass/Fail | | Yes | | |
| Resistance to wear | 6.1.1.7 | Pass/Fail | Declaration of value of abrasion | No | | |
| Watertightness | 6.1.1.8 | Pass/Fail | | Yes | | |
| 2 | Not relevant | | | | | |
| 3 | Release of dangerous substances | 6.1.3 | Indication of dangerous substances incl. concentration, etc. Or: "No dangerous substances" | | Yes | |
| 4 | Allowable surface gaps and voids | 6.1.4.1.1 | Gap/voids | | | |
| | | | For vehicles | Pass/Fail | Yes | |
| | | | Gap for use in longitudinal axis | Pass/Fail | Yes | |
| | | | Gap/voids/recess | | | |
| | | | - For cyclist | Pass/Fail | Yes | |
| | | | - For pedestrians | Pass/Fail | Yes | |
| | Level differences in the running surface | 6.1.4.1.2 | Level differences and steps between edge beams and centre beams in unloaded conditions | | Pass/Fail | Yes |
| | | | Level differences and steps between edge beams and centre beams under loaded conditions | | Pass/Fail | Yes |
| | Skid resistance | 6.1.4.2 | On carriageway | Declared value if relevant | Yes | |
| On footpath | | | Declared value if relevant | Yes | | |
| Drainage capacity | 6.1.4.3 | Pass/Fail (in case of drainage system) | | Yes | | |
| 5 | Not relevant | | | | | |
| 6 | Not relevant | | | | | |

| ER | Characteristics specified in the mandate | ETAG paragraph on product performance to be assessed | Class, use category, criterion | | No performance determined option |
|----|---|--|--------------------------------|---|----------------------------------|
| 7 | Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone | 6.1.7.1 | Corrosion | Pass/Fail (considering the working life category) | No |
| | | | Chemicals | Pass/Fail | No |
| | | | Ageing resulting from | | |
| | | | - temperature | Pass/Fail | No |
| | | | - UV radiation | Pass/Fail | No |
| | | | - ozone | Pass/Fail | No |
| | | | Resistance against freeze-thaw | Not relevant | |

6.1 KITS

6.1.1 Mechanical resistance and stability

6.1.1.1 General

6.1.1.2 Mechanical resistance

The product will be judged as fit for purpose for the designated use categories given in 2.2.1, provided that it satisfies the performance requirements in 4.1.1.2 by the verification procedure as described in 5.1.1.2.

6.1.1.3 Resistance to fatigue

The product will be judged as fit for purpose, provided that it satisfies the performance requirements in 4.1.1.3 by means of passing the verification procedures as described in 5.1.1.3.

6.1.1.4 Seismic behaviour

The selected approach in accordance with 4.1.1.4, and the relevant indications as in table 4.1.1.4 of Part 1, shall be declared and stated in the ETA. The verification shall be in accordance with 5.1.1.4.

The evaluation of a type of modular joint shall report which movement capacities/directions due to seismic events shall be restrained with additional measures (e.g. guides, not necessarily at the joint). In this case the effect of the seismic event in the restrained direction shall not be considered.

6.1.1.5 Movement capacity

The results of the verification of declared values according to the verification method given in 5.1.1.5 shall be stated in the ETA for the concerned directions. The results of the verification for the nominal movement capacity shall be stated in the ETA, including the reaction forces for:

- Horizontal movement capacity (longitudinal, transverse) in relation to skew and guide angle,
- Horizontal reaction forces,
- Rotation capacities in relation to relative vertical movements:

Permanent relative rotation angle $\dot{E} r_p$

This value is to be used in conjunction with the design situation given in combinations [G.8] and [G.14]. This value $\pm \alpha_p$ shall be equal to or greater than 2 %.

Accidental relative rotation angle $\dot{E} r_a$ (also for maintenance)

This value is to be used in conjunction with the design situation given in combinations [G.9]. This value $\pm \alpha_a$ shall be declared.

Cyclic relative rotation angle $\dot{\epsilon}_{r_f}$

This value is to be used in conjunction with the design situation given in combinations [G.13]. This value $\pm \alpha_f$ shall be declared.

The minimum clearances between the centre beams shall be declared.

The maximum skewness (angle between main axis of the bridge structure and the normal to the longitudinal axis of the joint) shall be declared.

6.1.1.6 Cleanability

Assessment shall be undertaken on the basis of analysis of the design. The kit will be judged as fit for use, provided that the geometry of the expansion joint demonstrates ability to extrude debris by movement, using the verification procedure as described in 5.1.1.6, and/or good accessibility for maintenance is provided.

6.1.1.7 Resistance to wear

The product will be judged as fit for purpose provided that it satisfies the performance requirements in 4.1.1.7 by means of passing the verification procedure as described in 5.1.1.7.

6.1.1.8 Watertightness

The assessment of whether the assembled kit remains watertight shall be undertaken according to the verification method given in 5.1.1.8.

If the Expansion Joint includes a connection between the joint and the waterproofing of the main structure, this connection shall be assessed with a pass/fail criterion.

6.1.2 Safety in case of fire

According to Part 1 of this ETAG 032: not relevant.

6.1.3 Hygiene, health and environment (ER 3)

6.1.3.1 Release of dangerous substances

The Expansion Joint shall comply with all relevant European and national provisions applicable for the uses for which it is brought to the market. The attention of the applicant shall be drawn on the fact that for other uses or other Member States of destination there may be other requirements which would have to be respected. For dangerous substances contained in the product, the NPD option (no performance determined) is applicable.

The expansion joint and/or constituents of the expansion joint listed in the EOTA TR 034: "General Checklist for ETAGs/CUAPs/ETAs -Content and/or release of dangerous substances in products/kits", which have to be considered will be verified by the given methods taking into account the installation conditions of the construction product and the release scenarios resulting from there. Regulations related to placing the product on the market may also need to be taken into account.

Regarding the release scenarios referred to in the EOTA TR 034, the use category S/W2 (Product with no direct contact to but possible impact on soil, ground and surface water have to be considered.

6.1.4 Safety in use

6.1.4.1 Ability to bridge gaps and levels in the running surface

6.1.4.1.1 Allowable surface gaps and voids

The expansion joint will be judged as fit for purpose, provided that it satisfies the performance requirements in 4.1.4.1.1 by means of passing the verification procedure as described in 5.1.4.1.1.

The ETA shall state the maximum angle β (relative to the traffic direction) related to the concerned user category.

6.1.4.1.2 Level differences in the running surface

Assessment for the unloaded condition shall be undertaken on the basis of analysis of the technical file and drawings. The maximum dimension of steps and the difference of the running surface levels shall be stated in the ETA.

For the loaded condition with loads associated with the characteristic combination of actions (SLS) by the maximum dimension of steps and the difference of the running surface levels according to the verification, given in 5.1.4.1.2, shall not exceed the value given in 4.1.4.1.2. The deflection shall be declared.

6.1.4.2 Skid resistance

Assessment shall be undertaken on the basis of analysis of the design. If required, the PTV (Pendulum Test Value) according to the verification method given in 5.1.4.2 shall be stated in the ETA.

6.1.4.3 Drainage capacity

Assessment shall be undertaken on the basis of analysis of the design according to 5.1.4.3.

6.1.5 Protection against noise

According to Part 1 of this ETAG 032: not relevant.

6.1.6 Energy economy and heat retention

According to Part 1 of this ETAG 032: not relevant.

6.1.7 Aspects of durability, serviceability and identification of the products

6.1.7.1 Aspects of durability

6.1.7.1.1 Corrosion

Assessment shall be undertaken on the basis of analysis of the Technical File according to 5.1.7.1.1.

The manufacturer shall declare the anticipated corrosivity category in accordance with the provisions of EN ISO 12944-2.

6.1.7.1.2 Chemicals

Assessment shall be undertaken on the basis of 5.1.7.1.2.

6.1.7.1.3 Ageing resulting from temperature, UV radiation and ozone

For components or materials which are susceptible to UV radiation, temperature, and ozone degradation, the assessment shall be undertaken according to 5.1.7.1.3 in conjunction with 6.2.

6.1.7.1.4 Resistance against freeze-thaw

Not relevant.

6.1.7.2 Aspects of serviceability

The assessment shall be undertaken according to the verification method given in 5.1.7.2.

6.1.7.3 Aspects of identification

The assessment shall be undertaken according to 5.1.7.3.

6.2 COMPONENTS

The Approval Body shall assess the possible effects on the performance of the expansion joint due to the variability of the elements and materials characteristics and, where applicable, declared tolerances.

The tables in Annex 8.M present assessment criteria for materials according to 4.2 and 5.2. For component materials not covered by the tables, appropriate assessment criteria shall be used. The Approval Body shall assess the fitness for purpose of the components based on the manufacturer's stated values.

Related tolerances shall be declared by the manufacturer and shall be assessed by the Approval Body in respect to possible effects on the performance of the product/kit.

7. ASSUMPTIONS AND RECOMMENDATIONS UNDER WHICH THE FITNESS FOR USE OF THE PRODUCTS IS ASSESSED

7.0 GENERAL

See Part 1 of this ETAG N° 032.

7.1 DESIGN OF WORKS

See Part 1 of this ETAG N° 032.

Further the design of the structure shall provide:

- Accessibility for inspection and replacement of components as described in Annex 8.M,
- Accessibility for repair and replacement of corrosion protection,
- In case of use in seismic areas, some types may require additional measures e.g. guides.

7.2 PACKAGING, TRANSPORT AND STORAGE

See Part 1 of this ETAG N° 032.

In addition to the assumptions, auxiliary structural measures shall be provided in order to prevent distortion and deformations during transport storage and installation. Where relevant, these structural measures shall be adjustable for installation purposes.

7.2.1 Packaging

See Part 1 of this ETAG N° 032.

7.2.2 Transport and storage

See Part 1 of this ETAG N° 032.

Care shall be taken to provide proper support conditions during transport and lifting operations so that damage to the joint by means of imposed deformations etc. does not occur. Lifting points and temporary supports shall be marked.

7.3 EXECUTION OF WORKS

See Part 1 of this ETAG N° 032.

The conditions and deviations from the theoretical geometry arising from centre beam butt joints on site shall not influence the support conditions of the joint.

For installation of joints in sloped running surfaces in combination with horizontally moving bearing surfaces, the bridge bearings shall be such that in mid position the running surface of the joint has the same plane as the running surface of the adjacent main structures.

7.4 MAINTENANCE AND REPAIR

See Part 1 of this ETAG N° 032.

Section three: ATTESTATION OF CONFORMITY (AC)

8. EVALUATION OF CONFORMITY

8.1 EC DECISION

See Part 1 of this ETAG N° 032.

8.2 RESPONSIBILITIES

8.2.1 Tasks for the manufacturer

8.2.1.1 Factory production control (FPC)

8.2.1.1.1 General responsibilities of the manufacturer

See Part 1 of this ETAG N° 032.

8.2.1.1.2 Control of incoming products and materials

Deviating from the guidance given in ETAG 032, Part 1, the following applies: the incoming materials and products, as well as their related certificates in accordance with EN 10204, shall comply with the requirements given in Annex 8.M.

8.2.1.1.3 Inspection and testing during production

See Part 1 of this ETAG N° 032 and in addition the guidance given in Table 8.1 applies.

Table 8.1: Inspection and testing in conjunction with production

| Procedure | Item | Standard/ specification | Requirement | Frequency |
|--|--|----------------------------|-----------------------------|---|
| Measurements, visual inspections | Main dimensions of the expansion joint (parts) in relation to the bridge cross section (elevation), including relevant dimensions of: - Kerb, - Footpath, and/or cycle road, - Gutter detailing, - On site edge and centre beam splice, - Other dimensions, site related, if relevant. See typical cross section (elevation), Figure 8.P.1 | | See manufacturer's drawings | 100 % |
| | Main dimensions of the expansion joint (parts) in the "horizontal" plane including skew angle, including relevant dimensions and evenness of: - Kerb, - Footpath, and/or cycle road, - Gutter detailing, - On site edge and centre beam splice, - Other dimensions, site related, if relevant. See typical plan view, Figure 8.P.2 | | See manufacturer's drawings | 100 % |
| | Presetting value (mm) | | See manufacturer's drawings | Completed joint, cross sections at 3 m pitch. |
| | Control system (Arrangement ⁽¹⁾) | | See manufacturer's drawings | 100 % |
| | | | | |

Table 8.1 (continued)

| Procedure | Item | Standard/ specification | Requirement | Frequency |
|---|--|--|--|---|
| Measurements, visual inspections | Joist beams, Centre beams and edge profiles: – characteristic and dimensions | | See manufacturer's drawings | 100 % |
| | Joist beams – Arrangement ⁽¹⁾ | | See manufacturer's drawings | 100 % |
| | Compression of prestress elements | | See manufacturer's drawings | 10 % |
| | Bolt torque | | See manufacturer's drawings | 10 % |
| | Corrosion protection: - Surface characteristics (roughness, cleanliness), - Dew point (Humidity, Air temperature, temperature of the parts), - Drying time, - Layer thicknesses, - Total layer thickness. | Corrosion protection manufacturers' requirements with reference to EN ISO 12944. | See dry film thickness stated on manufacturer's drawings | Test plan derived from EN ISO 12944-7, but not less than complete cross sections at 2 m pitch. On smaller parts, sample testing shall be carried out on 20 % of the areas covered with corrosion protection including critical locations. |
| | Predominantly dynamically loaded welded connections: - Recording of procedure, - Dimensional checks, - Free from defects, etc. | EN ISO 3834 Weld method statement, Weld method qualification | EN ISO 3834-2 See manufacturer's drawings, specifications | See EN 1090-2:2008, 12.4, with execution class EXC3 |
| | Predominantly statically loaded welded connections: Dimensional checks | | | |
| | Non-loaded welded connections Dimensional checks | | See manufacturers' drawings See manufacturer's drawings | See EN 1090-2:2008, 12.4 with execution class EXC2 |
| Connection of noise reducing elements to the centre beams and edge beams: - Welded connections, - Bolted connections, - Bolt torque. | See dynamically loaded welds | See dynamically loaded welds See manufacturer's requirements | See EN 1090-2:2008, ch 12.4 with execution class EXC3 | |
| Visual inspections | Seal: - Proper installation and clamping - Free from damage | | See manufacturer's drawings and/or specifications | To be defined between the manufacturer and the approved body |
| | Secondary welds - Free from defects etc. | | | |
| | Butt weld preparation of centre beams and edge beams | | | |
| | Marking for identification including CE marking | | | |
| | Information tag (order nr., Project, location, mass, presetting value) | | | |
| | State of sliding surfaces (roughness, cleanliness and lubrication) | | | |
| | Correct installation of bearings, prestress elements and control springs | | | |

(1): Arrangement means how the crossbeams are positioned in the structure, with their details.

8.2.1.1.4 Control of non-conforming products

See Part 1 of this ETAG N° 032.

8.2.1.1.5 Complaints

See Part 1 of this ETAG N° 032.

8.2.1.2 Prescribed Test Plan

Deviating from Part 1 of this ETAG N° 032, see 8.2.1 and Annex 8.M.

8.2.2 Tasks of the approved body

8.2.2.1 General

See Part 1 of this ETAG N° 032.

8.2.2.2 Initial Type Testing

See Part 1 of this ETAG N° 032.

8.2.2.3 Assessment of the factory production control system – Initial inspection and continuous surveillance

See Part 1 of this ETAG N° 032.

8.2.2.4 Certification

See Part 1 of this ETAG N° 032.

8.3 DOCUMENTATION

(1) The ETA

See Part 1 of this ETAG N° 032.

(2) Basic manufacturing process

Deviating from Part 1 of this ETAG N° 032, see 8.2 and Annex 8.M.

(3) Product and materials specifications

Deviating from Part 1 of this ETAG N° 032, see 8.2 and Annex 8.M.

(4) Test plan (as part of FPC)

Deviating from ETAG 032, Part 1, see 8.2 and Annex 8.M.

(5) Prescribed test plan

Deviating from ETAG 032, Part 1, see 8.2 and Annex 8.M.

8.4 CE MARKING AND INFORMATION

See Part 1 of this ETAG N° 032.

Section four: ETA CONTENT

9. THE ETA CONTENT

See Part 1 of this ETAG N° 032.

ANNEXES TO THIS ETAG FAMILY PART

Annexes 8-A to 8-L: for this family Part correspond to Annexes A – L in Part 1 of this ETAG N° 032, if applicable.

ANNEX 8.M: COMPONENTS FOR MODULAR EXPANSION JOINTS

- Materials
- Material testing and certificate levels
- Static testing of components
- Dynamic testing of components

Introduction

This annex describes requirements for the materials and assessment procedures to be used for the manufacturing of components for Modular Expansion Joints; the certificate levels in accordance with EN 10204 for incoming materials/components and where needed, the material type and production testing.

The requirements for the components and their materials are derived from the functions and the actions to which they are submitted. A general description of the requirements for components is given in Section 1 of this annex.

Detailed requirements for the materials for components are given in Section 2 of this annex.

For the components where a combination of materials, testing and levels of certificates requires full scale component testing, the basic requirements for static testing are given in Section 3 and the basic requirements for dynamic testing are given in Section 4 of this annex.

Section 5 describes the shear tests on bearings and prestress elements.

Section 6 describes the seal test.

SECTION 1, COMPONENTS AND FUNCTIONS

8.M.1.0 Components and functions

The working lives for fatigue and wear can also be expressed in numbers of cycles in relation to stress (or strain) intervals for fatigue and translation (or rotation) intervals for wear.

Further, see 2.3.4.1 and 2.3.4.2 of this Part 8.

| Category | | Assumed working life |
|----------|---|--|
| A | Non-replaceable | Equal to the assumed working life of the kit |
| B | Replaceable with <u>major</u> obstruction of the traffic flow | At least 0,5 times the assumed working life of the kit, but not less than 10 years |
| C | Replaceable with <u>minor</u> obstruction of the traffic flow | Not less than 10 years |

Explanation to the categories:

A: Replacement requires full destruction of the joint and/or its connection to the main structure.

E.g. for structures embedded in concrete and welded connections, except those mentioned under B.

B: Replacement requires major destruction of the joint and/or its connection to the main structure.

E.g. for bonded connections and welded connections in centre beams and crossbeams.

C: Replacement does not require destruction of the joint and/or its connection to the main structure.

E.g. for bolted and clamped connections of the seals.

8.M.1.1 General requirements for components

8.M.1.1.1 Chapter 4, Requirements

“The component shall fulfil its function over its assumed working life”.

This means that the effects of creep, relaxation, degradation of the materials etc. shall be limited to a level that they do not impair the function of the component during its assumed working life.

8.M.1.1.2 Chapter 5, Verification method

The loads and movements for components relevant for static behaviour, fatigue behaviour and wear, shall be derived from full-scale type testing of the kit in combination with 3-D analysis with respect to Annex G considering the loads and load combinations as given in Part 1, Annex G. In this way, for a particular sub-family, the characteristics for other joints within the production range can be derived from additional (if needed, FE-) analyses with interpolation or extrapolation.

The verification of components is carried out with reference testing of static, fatigue and wear resistance and testing of material characteristics for creep relaxation etc.

8.M.1.1.3 Chapter 6, Evaluation of the testing results

The test results shall demonstrate that the required load, fatigue and wear resistance, also considering the time dependent effects, meet the required capacities of the components to fulfil their function over the assumed working life.

8.M.1.2 List of components

In general, Modular Expansion Joints include the following components:

1. *Centre beam*

The centre beam carries the vertical and horizontal traffic loads with sufficient evenness and skid resistance. The traffic loads are transferred to the crossbeams. Further, it supports the seals between the centre beams and between the centre beams and the edge beams.

Note: The succession of centre beams and edge beams also provides skid resistance, however none of the existing skid resistance test methods is suitable to assess the skid resistance of the centre beams and edge beams.

Minimum assumed working life shall be category B.

2. *Edge beam*

The edge beam carries the vertical and horizontal traffic loads and transfers the loads into the main structures such as abutment and bridge. Further, it supports the seal.

Minimum assumed working life shall be category: A.

3. *Support beam (crossbeam)*

The support beam transfers the loads from the centre beams to the main structures. In addition to the load bearing function, it can slide or rotate in order to allow movements of the main structures without the locking solid of the main structures and the centre beams.

Minimum assumed working life shall be category: B

4. *Pantograph (crossbeam)*

The pantograph support acts as a crossbeam with a variable length by rotation of its parts. Further it acts as a control element for the centre beams.

Minimum assumed working life shall be category: B.

5. *Crossbeam box (joist box)*

The crossbeam box supports the crossbeams and ensures by its stiffness that the forces applied by the prestress elements are not susceptible to variation due to moving end supports surfaces.

Minimum assumed working life shall be category: A.

6. *Seal*

A seal functions as a barrier for the surface water to ensure the watertightness, it is flexible in all directions and does not carry the traffic loads.

Minimum assumed working life shall be category: C.

7. *Fixed and/or sliding bearing*

The bearing transfers the (traffic) loads from the centre beam to the crossbeam and/or to the main structure. The bearing can be fixed or sliding, in all cases it enables rotations. Rotations can cause reaction moments from deformation or friction in curved sliding surfaces.

Minimum assumed working life shall be category: C.

8. Prestress element

A prestress element prevents uplift of the centre beam to crossbeam connection and/or uplift in the crossbeam to main structure connection. A prestress element can be fixed or sliding and always has to allow rotations. Rotations can cause reaction moments from deformation or friction in curved sliding surfaces.

Minimum assumed working life shall be category: C.

9. Control elements

Control elements ensure that the centre beams are at approximately equal distances at the various opening positions of the modular joints.

Minimum assumed working life shall be category: C.

10. Anchor

Anchors ensure the connection of the expansion joint to the main structures.

Minimum assumed working life shall be category: A.

11. Additional surface elements (e.g. noise reducing)

Surface elements reducing the noise of traffic on the joint.

Minimum assumed working life shall be category: B.

SECTION 2, COMPONENTS FUNCTIONS AND CHARACTERISTICS FOR MATERIALS

Detailed requirements of the materials for components in relation to their functions

Tables 8.M.2.1 to 8.M.2.5 give for each component of the modular expansion joint:

- Designation,
- Loading conditions,
- Properties to be assessed with approval testing (type testing),
- Properties to be assessed with production testing (fingerprint testing),
- Level of certificate,
- Remarks, where needed.

For rubber and plastics the functional requirements cannot directly be transferred into criteria for the material characteristics. Therefore the relevant characteristics are given and, where relevant, it is indicated which minimum or maximum threshold levels are relevant for the suitability of these materials. These material characteristics and standard testing procedures are given in:

| | |
|-----------------------|--|
| Table 8.M.2.6a and 6b | Elastomer for seals |
| Table 8.M.2.7 | Elastomer for bearings, prestress elements and seals |
| Table 8.M.2.8 | Poly Tetra Fluor Ethylene (PTFE) for sliding surfaces |
| Table 8.M.2.9 | Ultra High Molecular Weight Polyethylene (UHMWPE), Polyamide (PA), Polyoxymethylene (POM), Polyethelene (PE), Polyurethane (PUR) |

For those materials not mentioned here, verification procedures shall be derived based on a proper analysis of their susceptibility to static (creep, relaxation) and dynamic (fatigue, wear) behaviour including the interaction with the weathering conditions.

Type testing of materials in relation to the requirements given in the Tables 8.M.2.6a, 8.M.2.7a, 8.M.2.8a and 8.M.2.9a can have one of the two following objectives:

1. Verification of threshold values given in the tables

In this case materials with characteristics beyond the limits given in the tables are not deemed to be suitable.

2. Establishing of trigger values

In this case the manufacturer is free to use any value, as long as the values are integrated in the design of the joint. The production tests shall show that the material has the same level of performance as the original material.

In both cases type testing shall be carried out on three test specimens, each specimen from a different charge. For the interpretation of the tests, the worst results from any charge shall be used.

Table 8.M.2.1: Requirements for materials of steel components

| Component/Part of System | Loading conditions and detailing | Assessed properties in Approval tests | Assessed properties in manufacturing tests | Certificate in accordance with EN 10204 | References |
|---|---|---------------------------------------|---|---|---|
| Steel component for misc. purposes | Non-loaded | | Geometry | - | - |
| Steel component e.g. cover plate | For statically loaded non-welded and welded components | | Geometry Yield point Tensile strength Elongation at break Chemical composition | 2.2 | Steel in accordance with EN 10025 |
| Steel component embedded in concrete e.g. edge profiles, boxes, anchorages | For dynamically loaded non-welded and welded components | | Geometry Yield point Tensile strength Elongation at break Chemical composition(C-eq.) Energy absorption (Charpy V) | 3.1 | Steel in accordance with EN 10025 Minimum S235J2 |
| Steel component e.g. Centre beam (Lamella) Crossbeam (Traverse) Noise reducing elements | For dynamically loaded non-welded and welded components | | Geometry Yield point Tensile strength Elongation at break Chemical composition(C-eq.) Energy absorption (Charpy V) | 3.1 | Steel in accordance with EN 10025 Minimum S235J2 for operating temperatures above -20 °C and S235K2 for operating temperatures below -20 °C to -40 ° C |
| Steel for sliding elements | - | | - | 3.1 | Austenitic steel in accordance with EN 10088-2 Grades 1.4401, 1.4404, 1.4571 or equivalent |
| Studs | - | | See certificate | 3.1 | Mat. EN ISO 13918 Welding: EN ISO 14555 |
| Bolts | For dynamically loaded connections | | See certificate Shall comply with reference standards given in EN 1993-1-8, 2.8 group 4 | 3.1 | Category C bolt class (8.8 and 10.9) EN 1993-1-8 Table 3.1 If Electrolytic Zink coated, then Fe/Zn 25 in acc. with ISO 2081, applied in accordance with EN ISO 1461. If made of austenitic steel, use EN 10088-2 Grades 1.4401, 1.4404, 1.4571 or equivalent. Thread compatibility |
| Bolts | For general purposes | - | Shall comply with reference standards given in EN 1993-1-8, 2.8 group 4 | - | EN 1993-1-8 Table 3.1 |

Table 8.M.2.2: Requirements for seals and seal clamping devices

| Component/Part of System | Loading conditions and detailing | Assessed properties in Approval tests | Assessed properties in manufacturing tests | Certificate in accordance with EN 10204 | Observation |
|---|---|--|--|---|--|
| Seal element (Elastomer EPDM, SBR and CR, mixture of SBR, CR and NR) <i>Function</i> Ensure watertightness and protection of the joint against debris | Contraction, elongation, shear deformation, weathering. Static clamping forces | Geometry (Analysis) | Geometry (Inspection) | 3.1 | The clamping devices can be integrated in the seals Certificate only applies to material. |
| | | Material testing and identification: See Table 8.M.2.6 | Material testing and identification: See Table 8.M.2.6 | | |
| | | Pull-out test Deformation test (including vulcanised section, if any). | | | |
| Seal clamping device <i>Function</i> Positive means of location for the seal component | Static clamping forces | Geometry (Analysis) | Geometry (Inspection) | - | The clamping devices can be integrated in the seals |
| | | Pull-out test | | | |
| | | Material testing and identification: See Tables 8.M.2.1 and 8.M.2.6 | Material testing and identification See Tables 8.M.2.1 and 8.M.2.6. | | |
| Geometry | Non loaded | Dimensions on drawing | Dimensions on drawing | - | Minimum thickness 4 mm |

Table 8.M.2.3: Requirements for bearing elements

| Component/Part of system | Loading conditions and detailing | Assessed properties in Approval tests | Assessed properties in manufacturing tests to be reported on certificate | Certificate in accordance with EN 10204 | Observation |
|---|---|--|---|---|---|
| <p>Bearing element</p> <p>(e.g. Polyamide, Polyoxymethylene, UHMWPE, NR or CR-with steel inserts, eventually with PTFE or other sliding surfaces against austenitic steel sheets)</p> <p><i>Function</i></p> <p>Transfer of vertical loads, accommodating translations and rotations</p> | <p>Static (prestress) and dynamic (traffic) loads.</p> <p>Depending on the detailing, sliding and imposed rotations can take place and shear forces can occur</p> | <p>Geometry</p> <p>Identification and assessment of material: see Tables 8.M.2.7, 8.M.2.8, 8.M.2.9.</p> | <p>Geometry</p> <p>Identification of material: see Tables 8.M.7, 8.M.2.8, 8.M.2.9</p> | <p>3.1 (elastomeric materials)</p> <p>2.2 (plastic materials)</p> | <p>Certificate applies for material</p> |
| | | <p>Integrated performance oriented assessment and testing:</p> <p>Load bearing test with creep and relaxation, see Section 3 of this Annex.</p> <p>Friction test (translation and/or rotation)</p> <p>Wear test (translation and/or rotation)</p> <p>Fatigue test</p> <p>For friction, fatigue and wear, see Section 4 of this annex</p> <p>Note: Use aged materials</p> | <p>Full scale component production test:</p> <p>Load deflection test</p> <p>(The necessity of production testing and test frequency are defined later)</p> | | |
| | | <p>Material testing and identification:</p> <p>See Tables 8.M.2.7, 8.M.2.8, 8.M.2.9 for rubber and plastic materials for components</p> | <p>Material testing and identification:</p> <p>See Tables 8.M.2.7, 8.M.2.8, 8.M.2.9 for rubber and plastic materials for components</p> | | |
| | | <p>Material characteristics for structural steel: Table 8.M.2.2: Minimum S235 in accordance with EN 10025</p> | <p>Material characteristics for structural steel products Table 8.M.2.2: Minimum S235 in accordance with EN 10025.</p> | | |
| | | <p>Steel for sliding surfaces in combination with PTFE shall be in accordance with EN 1337-2</p> | <p>Steel for sliding surfaces in combination with PTFE shall be in accordance with EN 1337-2</p> | | |

Table 8.M.2.4: Requirements for prestress elements

| Component/Part of System | Loading conditions and detailing | Assessed properties in Approval tests | Assessed properties in manufacturing tests to be reported on certificate | Certificate in accordance with EN 10204 | Remark |
|---|--|---|--|---|---|
| <p>Prestress element</p> <p>(e.g. NR or CR-with steel inserts, Polyurethane eventually with PTFE or other sliding surfaces)</p> <p><i>Function</i> Transfer of forces generated by imposed prestress</p> | <p>Static (prestress) and dynamic (traffic) loads.</p> <p>Depending on the detailing, sliding and imposed rotations can take place</p> | <p>Geometry</p> <p>Identification of material: see Tables 8.M.2.7, 8.M.2.8, 8.M.2.9.</p> | <p>Geometry</p> <p>Identification of material: see Tables 8.M.2.7, 8.M.2.8, 8.M.2.9</p> | <p>3.1 (elastomeric materials)</p> <p>2.2 (plastic materials)</p> | <p>Certificate applies for material</p> |
| | | <p>Integrated performance oriented assessment and testing:</p> <p>Load bearing test with creep and relaxation, see Section 3 of this annex.</p> <p>Friction test (translation and/or rotation)</p> <p>Wear test (translation and/or rotation)</p> <p>Fatigue test</p> <p>For friction, fatigue and wear, see Section 4 of this annex.</p> <p>Note: Use aged materials</p> | <p>Full scale component production test</p> <p>Load deflection test on 10 % of production, see Section 3 of this annex.</p> | | |
| | | <p>Material testing and identification:</p> <p>See Tables 8.M.2.7, 8.M.2.8, 8.M.2.9 for rubber and plastic materials for components</p> | <p>Material testing and identification:</p> | | |
| | | <p>Material characteristics for structural steel Table 8.M.2: Minimum 235 in accordance with EN 10025.</p> | <p>See Tables 8.M.2.7, 8.M.2.8, 8.M.2.9 for rubber and plastic materials for components</p> <p>Material characteristics for structural steel products Table 8.M.2.2: Minimum 235 in accordance with EN 10025</p> | | |
| | | <p>Steel for sliding surfaces in combination with PTFE shall be in accordance with EN 1337-2.</p> | <p>Steel for sliding surfaces in combination with PTFE shall be in accordance with EN 1337-2</p> | | |

Table 8.M.2.5: Requirements for control elements

| Component/Part of system | Loading conditions and detailing | Assessed properties in Approval tests | Assessed properties in manufacturing tests to be reported on certificate | Certificate in accordance with EN 10204 | Remark |
|---|----------------------------------|--|---|---|---|
| <p>Control element</p> <p>(e.g. Polyurethane, NR and CR with vulcanised steel parts, steel parts in mechanical structures dynamically loaded)</p> <p><i>Function</i></p> <p>Transfer of horizontal loads</p> | | <p>Geometry</p> <p>Identification of material: see Table 8.M.2.7</p> | <p>Geometry</p> <p>Identification of material: see Table 8.M.2.7.</p> | <p>3.1 (elastomeric materials)</p> <p>2.2 (plastic materials)</p> | <p>Certificate applies for material</p> |
| | | <p>Integrated performance oriented assessment and testing:</p> <p>Load bearing test with creep and relaxation, see Section 3 of this annex</p> <p>Wear test (translation and/or rotation)</p> <p>Fatigue test</p> <p>For wear and fatigue testing see Section 4 of this annex</p> | <p>Full scale component production test</p> <p>Load deflection test on 10% of production</p> | | |
| | | <p>Material testing and identification:</p> <p>See Tables 8.M.2.7 for rubber and plastic materials for components</p> | <p>Material testing and identification:</p> <p>See Tables 8.M.2.7 for rubber and plastic materials for components</p> | | |

Table 8.M.2.6a: Elastomeric characteristics for type testing of seal material

| Characteristic | Standard | Unit | Type test procedure | Requirement |
|-------------------------------|---|-------------------|---|--|
| Compound nr. | - | - | | Designation |
| Density | ISO 2781:2004 Technical corrections 1 1996 | kg/m ³ | | Result of test (declared value) The type test results are the basis for FPC |
| Hardness IRHD | ISO 48 ISO 7619-2:2006 | IRHD | | Result of test (declared value) The type test results are the basis for FPC |
| Tensile strength | ISO 37 | N/mm ² | | Result of test (declared value) The type test results are the basis for FPC |
| Elongation at break | ISO 37 | % | | Result of test (declared value) The type test results are the basis for FPC |
| Tear resistance | ISO 34-1 Method A | | | Result of test (declared value) The type test results are the basis for FPC If relevant |
| Compression set | ISO 815 B | % | 22 h 70 °C, 25 % constant deflection | ≤ 30 |
| Resistance to ageing | ISO 188, ISO 48, ISO 37 | | 7 days hot air 70 °C | With respect to un-aged material |
| | | IRHD | | - change of hardness: ≤ +7, |
| | | % | | - reduction of tensile strength: ≤ 20, |
| | | % | | - reduction of elongation at break: ≤ 30. |
| Resistance to de-icing agents | ISO 1817 | IRHD % | 14 days 23 °C, 4% kalium-chloride solution | reduced hardness: ≤ 5 increase of volume: ≤ 10 |
| Resistance to ozone | ISO 1431-1 | | Test procedure B, 20 % Elongation, 96 hrs (+0/-2) at 40 (± 2) °C. Ozone concentration 50 (± 5) pphm | No visible cracks |
| Brittleness temperature | ISO 812 | °C | 1. Method B at -35 °C 2. Method B at -50 °C | ISO 812, 7.1.1.4 For suitability at minimum operating temperature of -25 °C For suitability at minimum operating temperature of -40 °C |

Table 8.M.2.6b: Elastomeric characteristics for factory production control of seal material

| Characteristic | Standard | Unit | Production test procedure | Requirement | Frequency |
|---------------------|---|-------------------|---------------------------|---------------------------------------|-------------------------------|
| Compound nr. | - | - | - | Designation | Each batch or certificate 3.1 |
| Density | ISO 2781:2004 Technical corrections 1 1996 | kg/m ³ | - | Deviation from type test result: ≤ 50 | Each batch or certificate 3.1 |
| Hardness IRHD | ISO 48 ISO 7619-2:2006 | IRHD | - | Deviation from type test result: ≤ 5 | Each batch or certificate 3.1 |
| Tensile strength | ISO 37 | N/mm ² | | - | Each batch or certificate 3.1 |
| Elongation at break | ISO 37 | % | | - | Each batch or certificate 3.1 |
| Tear resistance | ISO 34-1 Method A | | | - | At least once a year |
| Compression set | ISO 815 B | % | 22 h, 70 °C | Deviation from type test result: ≤ 5 | At least once a year |

Table 8.M.2.7a: Elastomeric characteristics for type testing of material for bearings, prestress elements and control elements

| Properties | Standard | Unit | Type test procedure | Requirement |
|-------------------------|---|-------------------|---|--|
| Compound nr. | - | | | Designation |
| Density | ISO 2781:2004 Technical corrections 1 1996 | kg/m ³ | | Result of test (declared value) The type test results are the basis for FPC |
| Hardness IRHD | ISO 48 ISO 7619-2:2006 | IRHD | | Result of test (declared value) The type test results are the basis for FPC |
| Tensile strength | ISO 37 | N/mm ² | | Result of test (declared value) The type test results are the basis for FPC |
| Elongation at break | ISO 37 | % | | Result of test (declared value) The type test results are the basis for FPC |
| Tear resistance | ISO 34-1 | | Method A | Result of test (declared value) The type test results are the basis for FPC |
| Shear stiffness | ISO 1827 | N/mm ² | - | Result of test (declared value) The type test results are the basis for FPC |
| Compression set | ISO 815 B | % | 22 h at 70 °C, 25 % constant deflection | ≤ 30 |
| Resistance to ageing | ISO 188, ISO 48, ISO 37 | | 7 days hot air 70 °C, | With respect to un-aged material |
| | | IRHD | | - change of hardness: ≤ +7 |
| | | % | | - reduction of tensile strength: ≤ 20 |
| | | % | | - reduction of elongation at break: ≤ 30 |
| Resistance to ozone | ISO 1431-1 | | Test procedure B, 20 % Elongation, 96 hrs (+0/-2) at 40 (± 2) °C. Ozone concentration 50 (± 5) pphm | No visible cracks |
| Brittleness temperature | ISO 812 | °C | Method B at -35 °C | ISO 812, 7.1.1.4 |
| Adhesion | ISO 813 | N/mm | Peel at 90 °C Type of failure | Result of test (declared value) The initial type test results are the basis for FPC |

Table 8.M.2.7b: Elastomeric characteristics for factory production of bearings, prestress elements and control elements

| Properties | Standard | Unit | Production test procedure | Criteria | Requirement |
|----------------------|---|-------------------|---|--|-------------------------------|
| Compound nr. | - | | | Designation | Each batch or certificate 3.1 |
| Density | ISO 2781:2004 Technical corrections 1 1996 | kg/m ³ | | Deviation from type test: ≤ 50 | Each batch |
| Hardness IRHD | ISO 48 ISO 7619-2:2006 | IRHD | | Deviation from type test: ≤ 5 | Each batch |
| Tensile strength | ISO 37 | N/mm ² | | Deviation from type test: ≤ 10 | Each batch |
| Elongation at break | ISO 37 | % | | Deviation from type test: ≤ 10 | Each batch |
| Tear resistance | ISO 34-1 | - | | - | At least once a year |
| Shear stiffness | ISO 1827 | N/mm ² | | ≤ 0,2 | At least once a year |
| Compression set | ISO 815 B | % | 22h at 70 °C | Deviation from type test: ≤ 5 % | At least once a year |
| Resistance to ageing | ISO 188, ISO 48, ISO 37 | | 7 days hot air 70 °C, | With respect to un-aged material | At least once a year |
| | | IRHD | | - change of hardness: ≤ +7 | |
| | | % | | - reduction of tensile strength: ≤ 20 | |
| | | % | | - reduction of elongation at break: ≤ 30 | |
| Resistance to ozone | ISO 1431-1 | | Test procedure B, 20 % Elongation, 96 hrs (+0/-2) at 40 (± 2) °C. Ozone concentration 50 (±5) pphm | No visible cracks | At least once a year |

Table 8.M.2.8a: PTFE characteristics for sliding bearings, prestress elements and guides for type testing

| Properties | Standard | Unit | Type test procedure | Requirement | Note |
|--|------------|-------------------|---------------------|---------------|-------------------------|
| Compound nr. | | | | Designation | |
| Density | ISO 1183 | kg/m ³ | | 2 140 – 2 200 | |
| Hardness IRHD (Ball indentation hardness) | ISO 2039-1 | N/mm ² | H132/60 | 23 – 33 | |
| Tensile characteristics | ISO 527-2 | N/mm ² | | 29 – 40 | |
| Elongation at break | ISO 527-2 | % | | ≥ 300 | |
| Friction | See note | | | | See test in Annex 8.M.4 |
| Abrasion | See note | | | | See test in Annex 8.M.4 |

Note: Testing temperature at 23 °C ± 2 °C

Table 8.M.2.8b: PTFE characteristics for sliding bearings, prestress elements and guides for production testing

| Properties | Standard | Unit | Production test procedure | Requirement | Frequency |
|--|------------|-------------------|---------------------------|---------------|----------------|
| Compound nr. | | | | Designation | |
| Density | ISO 1183 | kg/m ³ | | 2 140 – 2 200 | Each batch (1) |
| Hardness IRHD (Ball indentation hardness) | ISO 2039-1 | N/mm ² | H132/60 | 23 – 33 | Each batch |
| Tensile characteristics | ISO 527-2 | N/mm ² | | 29 – 40 | Each batch |
| Elongation at break | ISO 527-2 | % | | ≥ 300 | Each batch |

(1) Each batch reported by material manufacturer

Table 8.M.2.9a; Material Characteristics for type testing of components of polyamide (PA), polyoxymethylene (POM) and polyethylene

| Characteristics | Standard | Type test procedure | Requirement | Note |
|------------------------------------|------------|--|-------------------|--|
| Compound nr. | | | | - |
| Density | ISO 1183 | | Test result | The type test results are the basis for FPC |
| Hardness IRHD | ISO 2039-1 | | Test result | The type test results are the basis for FPC |
| Tensile characteristics | ISO 527 | | Test result | The type test results are the basis for FPC |
| Shear strength | ISO 1827 | | Test result | The type test results are the basis for FPC |
| E modulus in tension | ISO 527 | | Test result | The type test results are the basis for FPC |
| Compressive strength | ISO 604 | | Test result | The type test results are the basis for FPC |
| E modulus in compression | ISO 604 | | Test result | The type test results are the basis for FPC |
| Elongation at break | ISO 527 | | Test result | The type test results are the basis for FPC |
| Tensile creep modulus | ISO 899-1 | | Test result | The type test results are the basis for FPC |
| Compression set | ISO 815 | 22h 70 °C, 25 % constant deflection | Test result | If relevant The type test results are the basis for FPC |
| Energy absorption (Charpy test) | ISO 179 | | Test result | The type test results are the basis for FPC |
| Resistance to low temperatures | ISO 812 | -25 °C, -40 °C | | See temperature range categories in Part 1 |
| Resistance to high temperatures | ISO 2578 | +50 °C | | The type test results are the basis for FPC |
| Resistance to ozone | ISO 1431-1 | Test procedure B, specified Elongation, 96 hrs (+0/-2) at 40 (± 2) °C. Ozone concentration 50 (± 5) pphm | No visible cracks | Elongation specification to be derived from design procedure |
| Friction | | Testing temperature at 230 °C ± 20 °C | | See test in Annex 8.M.4 |
| Abrasion | | Testing temperature at 230 °C ± 20 °C | | See test in Annex 8.M.4 |

(PE, including UHMWE: Ultra High Molecular Weight Poly Ethylene), Polyurethane

*Table 8.M.2.9b: Material characteristics for production components
of polyamide (PA), polyoxymethylene (POM) and polyethylene (PE, including UHMWPE), Polyurethane*

| Characteristics | Standard | Type test procedure | Requirement | Production test procedure | Requirement | Note |
|------------------------------------|-----------------|---|--------------------|----------------------------------|-----------------------------------|-------------------------|
| Compound nr. | | | | Designation | Designation | |
| Density | ISO 1183 | | Test result | | Max. 5 % deviation from type test | (1) Each batch |
| Hardness IRHD | ISO 2039-1 | | Test result | | Max. 5 % deviation from type test | Each batch |
| Tensile characteristics | ISO 527 | | Test result | | Max. 5 % deviation from type test | Each batch |
| Shear strength | ISO 1827 | | Test result | | Max. 5 % deviation from type test | Each batch |
| E modulus in tension | ISO 527 | | Test result | | Max. 5 % deviation from type test | If relevant |
| Compressive strength | ISO 604 | | Test result | | Max. 5 % deviation from type test | If relevant |
| E modulus in compression | ISO 604 | | Test result | | Max. 5 % deviation from type test | If relevant |
| Elongation at break | ISO 527 | | Test result | | Max. 5 % deviation from type test | Each batch |
| Tensile creep modulus | ISO 899-1 | | Test result | | | If relevant |
| Compression set | ISO 815 | 22 h 70 °C, 25 % constant deflection | Test result | | | If relevant |
| Energy absorption (Charpy test) | ISO 179 | | Test result | | Max. 5 % deviation from type test | Each batch |
| Friction | See note | | | | | See test in Annex 8.M.4 |
| Abrasion | See note | | | | | See test in Annex 8.M.4 |

Each batch reported by material manufacturer where relevant

SECTION 3, STATIC TESTING – MECHANICAL RESISTANCE TEST METHOD FOR COMPONENTS

8.M.3.1 Scope

This section describes the testing method for verifying the mechanical resistance of components for modular joints in relation to ULS and SLS load combinations, giving consideration to creep and relaxation where relevant.

8.M.3.2 Principles

The principle of this test is that a component is subjected to a load configuration (or imposed deformation) derived from the relevant static load combinations. The boundary conditions are modified in time so as to integrate creep and relaxation in one testing procedure, where relevant.

8.M.3.3 Samples and preparation of test specimens

The test pieces shall be full-scale components.

8.M.3.4 Load arrangements

The component related load and deformation arrangements on the specimens shall be derived from the appropriate load combinations (including the partial factors) as given in Part 1, Annex G, G.4.2, including the load and movement dispersal effects determined with field tests and analyses. The test load shall include the prestress effect F_{ik} , if any, and predicted creep and relaxation effects.

8.M.3.5 Testing arrangement and conditions

The component shall be mounted in a test frame in order to ensure that the imposed loads, deformations and rotations (which can be achieved using wedges) are compatible with the most adverse position for the as-built situation. The test frame shall be suitable to allow the build up of the forces during all test phases, and, if desired, to allow the impose deformations and rotations if needed.

If the temperature effects on the material properties are commonly known and well defined, the temperature of testing shall be between the selected temperature ranges of Part 1 of this ETAG 032.

If the mechanical properties of the material are affected by the temperature variation, this variation has to be defined in such a way that the properties for other temperatures can be derived by calculation.

If the temperature effects on the material properties are not commonly known and well defined for the temperatures of a selected range in accordance with Part 1, the component shall be tested at the lowest temperature $T_{min} -20\text{ °C}$ and the highest temperature $T_{max} +45\text{ °C}$.

8.M.3.6 Execution of the test

Due attention shall be given to rotations, eccentricities, imposed deformations and constraint effects, if they affect the load transfer at the sliding surfaces and through the component.

For creep testing, due attention shall be given to the continuous long-term load and the accuracy of the measuring equipment.

Phases 1 – 2 do not necessarily need to be carried out in the same testing rig with the same equipment as the phases 3 – 6.

| Phase | Load configuration | Load level on specimen determined from: | Time period |
|-------|--|---|--------------------------------|
| 1 | Application of prestress with quasi static traffic loads | $1,2 \times F_{1k} + 0,3 (Q_{1k} + Q_{2k} + Q_{3k})$ Opening position: 60% | < 5 min. |
| 2 | Constant loads (Creep test) | See Phase 1 | See comment 1 See comment 2 |
| 3 | Application of Serviceability Limit State loads | C _{SLS} as given in Annex G, Part 1 | < 5 min. |
| 4 | Release the load | 0 | 72 hrs. See comment 3 |
| 5 | Application of Ultimate Limit State loads | C _{ULS} as given in Annex G, Part 1 | < 5 min. |
| 6 | Post-critical behaviour at Ultimate Limit State loads | See Phase 5 | 1 hr. |

Comment 1: Typical load and deflection curves are given in Figure 8.M.3.1.

Comment 2: Creep testing is only relevant for bearings and prestress elements and can be omitted for control elements.

Comment 3: Record the recovery behaviour of the component.

Load and Deformation of Load bearing test

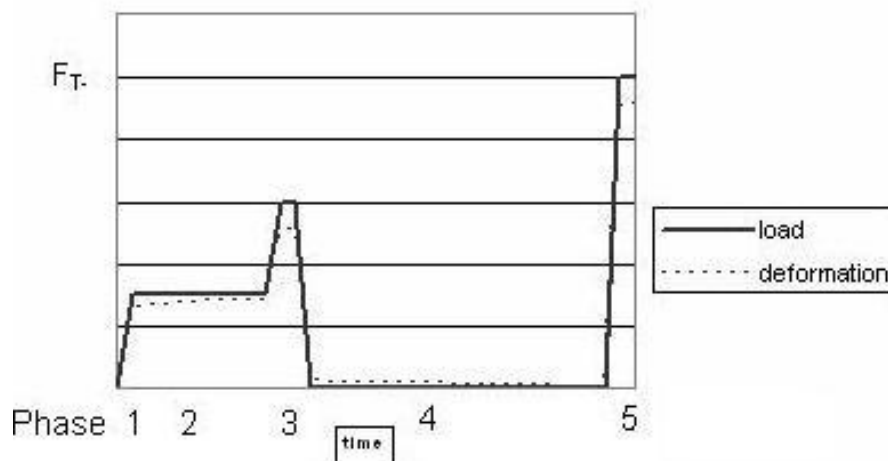


Figure 8.M.3.1: Typical Load-Deformation curves

Measurements, inspections and evaluations for all phases:

- Deflections (maximum, minimum and mean values) with 5 % accuracy,
- Applied loads and loading rate with 5 % accuracy,
- At phase 3 and 4, the specimen shall be inspected for plastic deformations,
- Creep ratio with 5 % accuracy,
- Debonding effects, if any,
- Cracks, if any,
- Exceptional behaviour,
- Failure mode, if any,
- Determine the load-deflection curves.

8.M.3.7 Pass/fail criteria

- The measured deformations, creep and relaxation shall stay within the limits put by the bearing-prestress element assembly in conjunction with the assumed working life of the components.
- No plastic deformations at SLS level.
- Cracks and/or debonding effects at ULS shall not cause damage to the joint.
- No brittle behaviour at ULS.

8.M.3.8 Test report

The test report shall include the following:

- Name of the manufacturer and production centre,
- Name and signature of testing body,
- Model identification (type, theoretical movement capacity, N° of batch),
- Drawings,
- Material specifications,
- Reference to this annex and any deviation from it,
- Description of the test equipment,
- Date of the preparation of specimens, the date of test and the test temperature,
- Dimensions of test specimens,
- Report of observed phenomena and pass/fail criteria according to 8.M.3.6 and 8.M.3.7,
- Photos of relevant at least before and after testing situations.

SECTION 4, DYNAMIC TESTING, RESISTANCE TO FATIGUE AND WEAR OF COMPONENTS

8.M.4.1 Scope

This section describes the method for verifying the resistance to fatigue and wear of components for Modular Expansion Joints. The test method includes the effects of the accumulation of wear of the sliding surfaces.

8.M.4.2 Principles

The principle of this test is to apply movement (Phase 1) and load cycles (Phase 2) on the components. The movements and loads are derived from reference movements and loads considered as simulations of movements and traffic loads in practice.

Hereafter, a general dynamic testing procedure is described. Analysis of the load transfer of the joint shall indicate whether all tests have to be carried out or whether specific phases shall be disregarded.

8.M.4.3 Samples and preparation of test specimens

The test pieces shall be full-scale components. Seals shall comprise a butt joint as prepared on site, if part of the design.

8.M.4.4 Movement and load arrangements

The component related load and deformation arrangements on the specimens shall be derived from the appropriate load combinations (including the partial factors) as given in Part 1, Annex G, G.4.2, including the load and movement dispersal effects determined with field tests and analyses.

8.M.4.4.1 Bridge movement due to temperature on the bridge (Phase 1)

The total slide path for the test procedure in relation to a working life of "a" years of a component is derived from:

$a \times 365 \times 0,33 \times \text{maximum movement capacity} = 120 \times a \text{ cycles with maximum movement capacity of the joint.}$

For Working life categories B and C: $a = 10$.

The wear test on the component shall be carried out with the prestress of the built-in component taking account of creep and relaxation if any.

8.M.4.4.2 Traffic loads (Phase 2)

Depending on the composition of the components, a choice shall be made between applied loads derived from FLM1_{EJ} or FLM2_{EJ}. The loads shall be applied for the most adverse boundary conditions in conjunction with a 60 % opening position of the joint.

1. Fatigue Load Model for expansion joints FLM1_{EJ} to verify an unlimited life with respect to fatigue.

The test parameters shall be derived from:

- Vertical axle load: $\Delta\phi_{fat}^{(1)} \cdot 0,7 \cdot Q_{1k} = 1,3 \times 0,7 \times 300 = 273 \text{ kN}$
- Horizontal axle load: $\Delta\phi_{fat} \cdot 0,7 \cdot 0,2 \cdot Q_{1k} = 1,0 \times 0,7 \times 0,2 \times 300 = 42 \text{ kN}$
- Minimum number of cycles: 5×10^6
- Wheel print l x b (mm): 300×250

(1) The dynamic amplification factor can be reduced based on field tests.

or:

2. Fatigue Load Model for expansion joints FLM2_{EJ} to establish an S-N relationship from which a fatigue design life can be derived.

The test parameters shall be derived from the distribution and the combinations of vertical and horizontal axles loads as given in Part 1, Annex G, Table G3.

The dynamic amplification factor, included as a factor 1,3 in the axle loads of Table G.3, can be reduced based on field tests.

The test loads for fatigue include a partial factor $\gamma_{Ff} = 1,0$.

8.M.4.5 Execution of the test

A specimen shall be subjected to Phase 1 and subsequently to Phase 2.

Due attention shall be given to rotations, eccentricities, imposed deformations and constraint effects, if they affect the load transfer at the sliding surfaces and through the component.

Phase 1, wear and friction test

- Apply a load F_{ik} with 5 % accuracy.
- Apply cyclic movements with a minimum mean velocity of 4 mm/s on the test specimen. The amplitudes shall be derived from amplitudes of ± 33 % of the total movement capacity of the joint (one complete cycle corresponds to 67 % of the total movement capacity of the joint).
- The required number of cycles is derived from the working life of the component.
- If the temperature of the specimen exceeds 35 °C, the test may be interrupted.

Measurements during phase 1

- Measure the (initial) static and dynamic friction coefficients during 10 cycles, at the beginning of the test, at intervals of 1 000 m slide path and after every dwell period.
- Measure the wear of the specimen after each phase by weighing of the specimen and measuring the dimensions of the specimen before and after the test phases. Inspect the sliding surfaces.

Phase 2, Fatigue test

The test shall be carried out at ambient temperature (between +5 °C and +35 °C) and the test loads shall be derived for an opening position of the joint, which is 60 % of the maximum opening position of the joint.

Apply the cyclic loads resulting from a structural analysis in accordance with the procedure given in 8.M.4.4.2 and, where relevant, consider the effect of preload on the component.

Note: Resulting loads can be: Compression only, Alternating or Tension only.

Approach 1, Unlimited fatigue life

If, after being subjected to 5×10^6 cycles, the component has not collapsed or does not show damage, it can be assumed that the fatigue life of the component is unlimited.

Approach 2, Limited fatigue life

The fatigue resistance of the component shall be derived from various tests, which shall be run to collapse or cracking of the component. The test results shall be transferred into an S-N line.

8.M.4.6 Expression of the results

The following results shall be reported:

Phase 1

- The (initial) static and dynamic friction coefficients during 10 cycles, at the beginning of the test, at intervals of 1 000 m slide path and after every dwell period,
- The loss of mass of the specimen after each phase, the dimensions of the specimen before and after the test phases,
- The condition of the sliding surfaces,
- Reaction forces during the test,
- Deformations,
- Debonding,
- Cracking,
- Displacements,
- Changes in preload if any.

Phase 2

- Applied loads,
- Deflection and deformations,
- Cracks,
- Exceptional behaviour,
- Mode of failure,
- Expected working life.

8.M.4.7 Test report

The test report shall include the following:

- Name of the manufacturer and production centre,
- Name and signature of testing body,
- Model identification (type, theoretical movement capacity, N° of batch),
- Drawings,
- Material specifications,
- Reference to this annex and any deviation from it,
- Description of the test equipment,
- Date of the preparation of specimens, the date of test and the test temperature,
- Dimensions of test specimens,
- Report of observed phenomena according to 8.M.4.6,
- Photos of relevant testing situations.

SECTION 5, SHEAR TEST FOR BEARINGS, PRESTRESS AND CONTROL ELEMENTS

8.M.5.1 Scope

This section describes a shear test for bearings, prestress elements and control elements of modular joints if one of the principal deformations in use occurs due to shear loads.

8.M.5.2 Test specimen

The tests specimen shall represent a full scale bearing, prestress and/or control element.

8.M.5.3 Testing arrangement

The specimen shall be supported and clamped in the testing equipment with similar boundary conditions as occurring in the kit (expansion joint) in real built-in situations. Testing in sets (using symmetry and asymmetry for the support conditions, simultaneous testing of several specimens in one test set-up) is allowed, as long as the boundary conditions are not affected in an adverse manner.

8.M.5.4 Execution of the test

Derive the loads and applied deformations from the design of the joint for the relevant static and dynamic design situations. Adjust the combination of resulting unfavourable loads and deformations by a factor 1,2 and of favourable loads and deformations by a factor 0,9 for the static test and 1,0 for the dynamic test.

The loading frequency shall be determined by field tests in accordance with Annex 8.O or derived from the lorry speeds given in Table 8.O.7.2 and the wheel prints given in Annex G of Part 1.

Static test

Apply the load/deformation range as given above.

Dynamic test

Apply the number of cycles related to the wear test procedure as given in 5.1.1.7 for the load/deformation range as given above.

8.M.5.5 Pass-fail criteria

For the shear stiffness no criteria for static and dynamic stiffness can be given. The values resulting from the tests shall be used for design purposes of the expansion joint (kit).

SECTION 6, SEAL TEST

8.M.6.1 Scope

This section describes the seal test, which is meant to investigate the performance of the seal and its clamping devices under more extreme conditions simulating strain conditions resulting from debris with respect to movements (opening and closing) for new and aged material.

This test is only meant for type testing.

8.M.6.2 Test specimen and test set up

The test specimen consists (new and aged material to Table 8.M.2.6a) of two edge profiles with a length of 500 mm, which are connected to a seal element of the same length. The edge profiles are mounted in the test rig creating similar conditions as in a realistic joint.

One specimen shall be manufactured from new and one from artificially aged material (see Table 8.M.2.6a).

8.M.6.3 Execution of the test

The starting point of each test is the seal in a neutral position, without internal forces in the seal.

1. Phase 1. Move one of the edge profiles in the horizontal dilatation direction thus stretching the seal to a horizontal position (maximum "geometrical stretched position" without relevant tension in the seal). The dilatation opening shall be at least the maximum nominal dilatation capacity for one seal.
2. Phase 2. Apply an additional horizontal displacement equal to 20 % of the gap dimension of phase 1, in combination with a vertical displacement equal to 40 % of the gap of one end of the displaced edge profile. Keep this position for 24 hrs.

The applied forces shall be recorded in relation to the displacements.

8.M.6.4 Evaluation

During and after the test, the seal element shall not be shifted in its clamping connections, detached, cracked or broken.

8.M.6.5 Test report

The test report shall give a full description of the execution of the test including the failure mechanisms if any.

Annex 8.N: (Quasi) Static and Fatigue Requirements and Assessment of Modular Expansion Joints

8.N.1 Introduction

By selecting the most adverse combinations of loads and imposed deformations, the static resistance of the expansion joint can be assessed.

8.N.2 Objective

(Quasi-) static and fatigue assessment of the joint.

8.N.3 Principles

The principle of this assessment is that for all parts and components static and fatigue limit state considerations are applied. Fulfilling the requirements associated with these limit states gives confidence about the resistance of the joint as a whole. Component test results can be used to demonstrate that the requirements for the design situations are met. Results from field testing can be used for the determination of the load transfer.

8.N.4 Scope

The guidance given in this annex applies to all types of modular joints.

8.N.5 Overview of requirements and aspects to be assessed

The table in Part 1 of this ETAG 032 is further detailed for Modular joints as follows:

Table 8.N 1: Guidance for limit state assessment

| Limit state | Limit state requirement and guidance for assessment | Component specific guidance |
|---|---|--|
| <p>ULS, fundamental combination</p> | <p>Static equilibrium (No internal failure or excessive deformation).</p> <p>Vertical and horizontal effects shall be combined as given in ETAG 032 Part 1, Annex G.</p> | <p><i>Centre beam and Edge beam</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ <p><i>Connection of centre beam to crossbeam</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ <p><i>Crossbeam</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Span in conjunction with combination rules in ETAG 032 Part 1 Annex G, 4.2.1 • Horizontal fixing and guide function • Partial factor $\gamma_{M2} = 1,25$ <p><i>Bearing</i></p> <ul style="list-style-type: none"> • Load bearing capacity (deformation criterion) • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ <p><i>Prestress elements</i></p> <ul style="list-style-type: none"> • Separation of contact surfaces allowed • Partial factor $\gamma_{M0} = 1,0$ <p><i>Control elements</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ <p><i>Seal element</i></p> <ul style="list-style-type: none"> • Not relevant <p><i>Joist box</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ <p><i>Anchorage system (including that of the joist box)</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Reinforcement design in accordance with EN 1992 • Welding of studs in accordance with EN ISO 13918 • Partial factor $\gamma_{M0} = 1,0$ <p><i>Top segmental (Noise reducing) elements and their connections</i></p> <ul style="list-style-type: none"> • Full plastic behaviour • Section forces and moments from Elastic system • Partial factor $\gamma_{M0} = 1,0$ |
| | <p>No fatigue failure Stress ranges below constant amplitude fatigue limit (CAFL) or cumulative damage assessment $D < 1,0$</p> <p>Section forces and moments from Elastic system enlarged with dynamic factors from testing, Annex 8.O</p> <p>Vertical and horizontal effects shall be combined. Phase shift based on dynamic analysis is allowed. See Annex 8.O.8.5</p> <p>Test results from component assessment Annex 8.M</p> <p>Or: Use of small scale tests for classification Relevant standards: EN 1993-1-9, EN 1999</p> <p>Note: Dislocation or other failure of bearings, prestress elements or control elements may lead to progressive fatigue collapse due to redistribution of internal load transfer</p> | <p><i>Centre beam with splices</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,15$ <p><i>Edge beam</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,15$ <p><i>Connection of centre beam to crossbeam</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,15$ <p><i>Crossbeam</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,35$ <p><i>Joist box</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,15$ <p><i>Bearing</i></p> <ul style="list-style-type: none"> • Partial factor to be determined in accordance with EN 1990 <p><i>Prestress elements</i></p> <ul style="list-style-type: none"> • Partial factor to be determined in accordance with EN 1990 <p><i>Control elements</i></p> <ul style="list-style-type: none"> • Partial factor to be determined in accordance with EN 1990 <p><i>Seal element</i></p> <ul style="list-style-type: none"> • No partial factor as no load bearing capacity <p><i>Anchorage system</i></p> <ul style="list-style-type: none"> • Reinforcement design in accordance with EN 1992 • Studs in accordance with EN ISO 13918 • Welds in accordance with EN 1993-1-9 • Partial factor to be determined in accordance with EN 1990 <p><i>Top segmental (Noise reducing) elements and their connections</i></p> <ul style="list-style-type: none"> • Partial factor $\gamma_{Mf} = 1,15$ |

| Limit state | Limit state requirement and guidance for assessment | Component specific guidance |
|---------------------------------|--|---|
| ULS | Wear See Annex 8.M | Bearing, Prestress element, Sliding plate and Control system <ul style="list-style-type: none"> • Thickness reduction • Increased friction coefficient • Generation of play (possibility to move) • Change of prestress |
| Accidental limit state | Static equilibrium (No internal failure or excessive deformation). Vertical and horizontal effects shall be combined as given in; See ETAG 032 Part 1, Annex G, G.4.2.2 | See ULS |
| Seismic design situations | Static equilibrium (No internal failure or excessive deformation). Vertical and horizontal effects shall be combined as given in; See ETAG 032 Part 1, Annex G, G.4.2.3 | See ULS, considering selected failure modes ETAG 032, Part 1, Table 4.1.1.4 |
| SLS, characteristic combination | Deformations, displacement or rotation reversible Crack opening limits Traffic safety Gaps and unevenness due to deflections at Frequent load combination and SLS See ETAG 032 Part 1, 4.1.4.1 Vertical deflection for complete joint under traffic loads | Centre beam Connection of centre beam to crossbeam Crossbeam Edge beam Crossbeam to joist box connection Bearing Prestress element Control elements Anchorage system Top segmental (Noise reducing) elements |

Annex 8.O: Dynamic assessment and field testing

8.O.1 Introduction

A modular joint is a kit, assembled from components. The specific test loads and boundary conditions for the components and the kit cannot be concluded from analysis only, which causes the need for field-testing in conjunction with 3-D (e.g. Finite Element) analyses.

This annex describes how field tests of the kit shall be arranged and carried out and how the dynamic behaviour can be evaluated. Here, field-testing means that tests are carried out on full-scale joints which can be situated in an existing road or at testing facilities.

8.O.2 Objective

The objective of this test method is to derive the dynamic properties, dynamic factors for vertical and horizontal loads, system and material damping, free vibration, the (dynamic) loads for the kit and boundary conditions for the component testing, where necessary.

8.O.3 Principles

The principle of this test is that a full-scale joint is subjected to moving loads exerted by a reference lorry (over rolling test) and that the measurements, e.g. carried out by accelerometers, strain gauges and recordings of laser signals enable a proper dynamic analysis.

Design aspects based on testing shall be in accordance with EN 1990, Annex D.

As the dynamic investigation does not need a higher accuracy than approximately 10 %, one test arrangement, subjected to a passing test lorry with different speeds, is sufficient.

Simultaneously to the test, a 3-D (Finite Element) Model is established of the kit, which is used to derive eigenfrequencies and eigenvectors to obtain knowledge and insight with which the performance of modular joints with other numbers of seals can be derived.

The results of the test and analyses apply for joints of the same type, but with other dimensions, provided the calculated vertical, horizontal and rotation natural frequencies do not fall below 90% of those of the originally tested and analysed expansion joint. When the natural frequencies are higher, the dynamic response will be smaller than that of the tested joint and the tested values can be used as a safe assumption.

8.O.4 Scope and range of application

The evaluation of test results based on this annex is applicable for joints loaded by one axle in the traffic direction only (expansion joint width approximately 1 200 mm). For larger joints the test results can be used in conjunction with additional analyses.

The dynamic assessments described in this annex are based on joints positioned perpendicular to the traffic direction and perpendicular to the main axis of the bridge.

Joints not perpendicular to the traffic direction will show a smoother load application effect and therefore can be considered included. Skew joints are considered covered by investigations on perpendicular joints, if their dynamic properties are equal to perpendicular joints.

For joints with spatial detailing e.g. horizontal bends and or radii, maybe in combination with vertical bends, additional analyses will be needed.

8.O.5 Samples and preparation of test specimens for over rolling tests

The test pieces shall be full-scale joints with a minimum of three centre beams with a minimum length of six intermediate spans and two cantilever parts (this expansion joint would in practice be suitable for a dual lane motorway with an emergency lane). The centre-to-centre distance of the crossbeams shall be at least 80 % of the maximum theoretical value. The cantilevering of the centre beams shall be approximately 30 % of the intermediate centre beam spans. The joint direction shall be perpendicular to the traffic direction.

The expansion joint shall be in a good state, with no parts missing or deficient. The evenness of the joint shall meet the manufacturer's design specifications. The evenness of the adjacent pavement shall be of medium quality (See EN 1991-2, 4.2.1, Note 3). The alignment shall be smooth, without discontinuities.

Provided that the materials for the components meet the detailed requirements given in Annex 8.M, the ageing process during the design life of the components (wear, relaxation) can be considered not to cause significant modification of the assembled "spring" characteristics at the connections, supports etc. If the materials are not subject to a detailed specification in Annex 8.M, the ageing effects shall be analysed and considered for the tests described here.

8.O.6 Testing arrangement and conditions

8.O.6.1 Location and conditions

The joint is located in a (preferably: test) road and installed similarly to real "built-in" situations. As the modular joint is predominantly a steel structure with springs, sliding surfaces and hinges, the tests are carried out at ambient temperatures (between +5 °C and +35 °C).

8.O.6.2 Proposed type

Minimum of 4 seals (3 centre beams).

8.O.6.3 Instrumentation

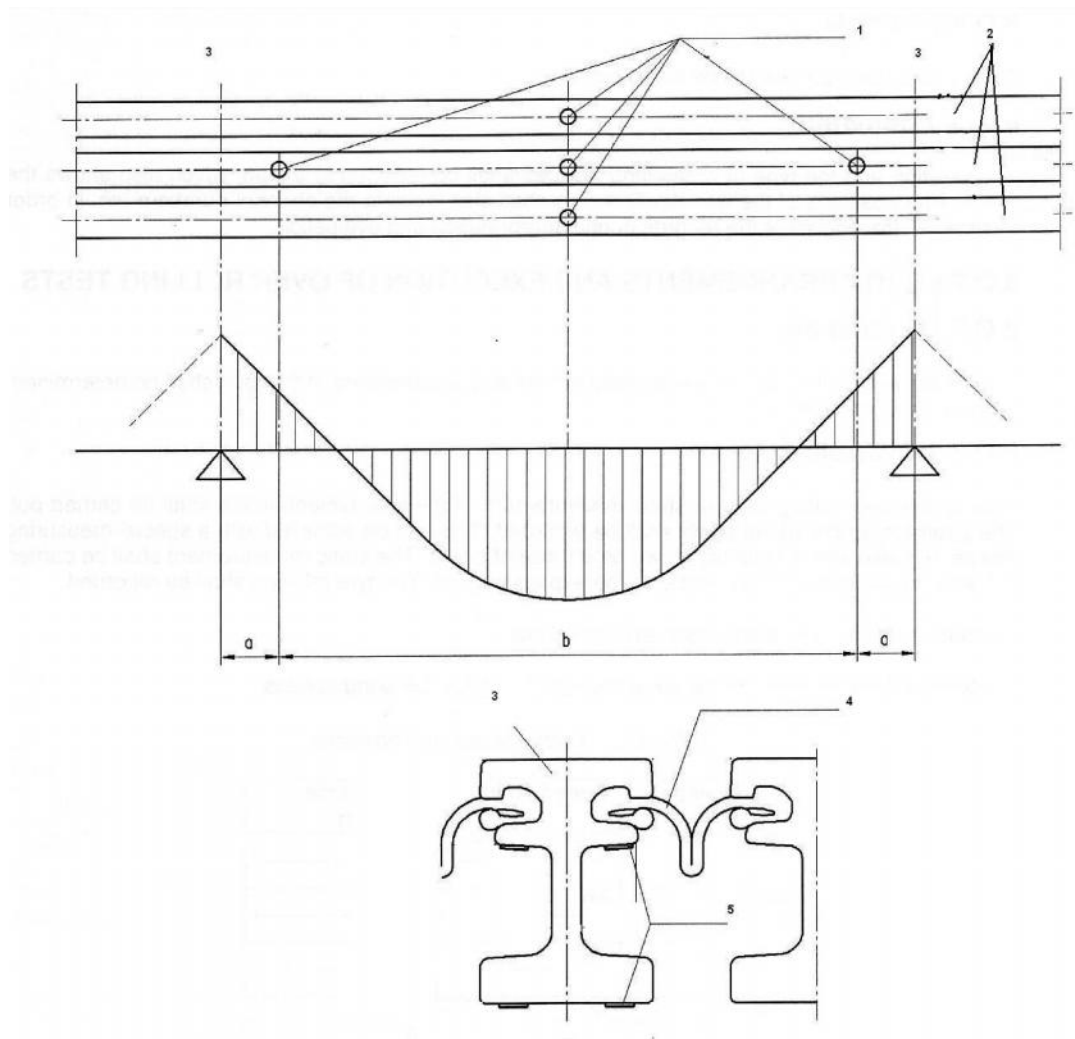
The instrumentation of the expansion joint shall consist of a combination of accelerometers, strain gauges and displacement sensors on the centre beams and crossbeams. The instrumentation shall allow a clear analysis of solid body motions, vertical bending, horizontal bending, torsion and/or tilting. The sampling frequency of the instrumentation shall allow a proper analysis of the dynamic behaviour. In general, the instrumentation and data acquisition is adequate when the natural frequencies in vertical and horizontal direction and with respect to torsion (Tilting) can be derived.

A minimum sampling frequency of 1 500 Hz is recommended for the data acquisition, because the natural frequency of many structures is approximately 120 Hz.

8.O.6.4 Centre beams

Three neighbouring centre beams shall be instrumented with strain gauges, the same span of each centre beam. The instrumented span should be the one but last. Each centre beam shall have three instrumented cross-sections with 4 strain gauges (see Figure 8.O.6.4) (one near the support and one at midspan) in order to facilitate the derivation of vertical and horizontal bending moments in the cross sections. If the load transfer conditions for the over rolling vehicle are almost the same for each centre beam, the strains at the support locations only have to be measured at the middle centre beam (see Figure 8.O.6.4). For practical reasons, the strain gauges at the support locations may be placed at a small distance from the support. In that case, the measurements shall be corrected for that.

For braking and acceleration tests the horizontal displacement of the supports shall be measured.



Key: 1: Location of strain gauges, 2: Centre beams, 3: Support bar, 4: Seal element, 5: Strain gauge

Figure 8.0.6.4: Typical arrangements of strain gauges on centre beams

The strain gauge positions shall be accurately defined and reported because the strains will be used for the calculation of bending stress diagrams in relation to vertical and horizontal bending moments.

As an alternative, the strain gauge measurements can be replaced by displacement measurements. In this case, due attention shall be paid to obtain relative displacements for each centre beam in order to enable a proper derivation of section forces and section moments.

8.0.6.5 Crossbeam

For the crossbeams the measurements may be limited to the vertical load transfer. The load transfer (section moments) can be derived from strain gauge measurements or displacement measurements. Displacement measurements shall include the crossbeam deflection and the crossbeam support displacements.

8.0.6.6 Joint extremities (cantilevers) and other discontinuities

The joint extremities with cantilevering parts larger than 0,3 times the intermediate spans (free cantilevering centre beam etc.) and other discontinuities shall be verified with additional accelerometers. The results (Frequencies, eigenvectors, accelerations) shall be used for calibration of 3D (e.g. FE) models.

8.O.6.7 Vehicle

The vehicle (see 8.O.7.2) does not need to be instrumented.

8.O.6.8 General

The position and the type of measuring devices shall be reported in a plan, which also shows the over rolling positions of the wheels. The plan shall also indicate the channel numbers etc. in order to allow full traceability of the records during interpretation and evaluation.

8.O.7 Load arrangements and execution of over rolling tests

8.O.7.1 Excitation

Prior to the over rolling test, the eigenfrequencies and eigenvectors of the joint shall be determined (e.g. excited by a hammer).

8.O.7.2 Over-rolling test

Prior to the over rolling tests, a static measurement of the axle (wheel) loads shall be carried out. The geometry of the wheel prints shall be recorded. This can be achieved with a special measuring device, but also with a contour, drawn on a piece of paper. The static measurement shall be carried out with the same transverse slope as the expansion joint. The tyre inflation shall be recorded.

Subsequently the over-rolling tests are carried out:

A reference lorry travels over the expansion joint with the following speeds:

| Sequence | Speed (km/h) | Transverse Position |
|----------|--------------|---------------------|
| 1 | ≤ 5 | A |
| | | B |
| 2 | 50 | A |
| | | B |
| 3 | 70 | A |
| | | B |
| 4 | 90 | A |
| | | B |

Table 8.O.7.2: Lorry speeds and positions

A - Maximum effect on centre beams

At least one wheel of every axle (left or right) passes the midspan of the middle centre beam (of the three instrumented centre beams) with a tolerance of 10 % of the span length.

B - Maximum effect on crossbeams

At least one wheel of every axle (left or right) passes the support of the middle centre beam (of the three instrumented centre beams - centre of crossbeam) with a tolerance of 10 % of the span length

Sequence 1 simulates a static load transfer through the joint. Sequences 2 – 4 generate dynamic load transfer through the joint.

The vehicle speeds may be achieved by cruise control or manually and shall be recorded.

The (transverse) position of the over rolling wheels and the distances to the centre beam supports shall be reported.

It is recommended to record the dynamic wheel print length (e.g. pictures (video) at real speed).

The centre-to-centre distances and the width of the centre beam flanges shall be reported (gap width).

The as-built drawings of the joint (and its components) are part of the documentation of the test set up.

The following lorry types are recommended:

- Two axle lorry with axle loads as EN 1991-2 FLM4 Type 1: Front axle 70 kN and rear axle 130 kN.
- Five axle lorry with axle loads as EN 1991-2 FLM4 Type 3: Tractor: Front axle 70 kN, Rear axle 150 kN, Trailer tridem 3 x 90 kN.

8.O.7.3 Braking and acceleration tests

The braking test is carried out for the investigation of maximum braking effects on the joint and the acceleration test is carried out for the investigation of maximum acceleration effects on the joint.

A reference lorry travels over the expansion joint with the following speeds:

| Sequence | Start/End speed (km/h) | Transverse position | Movement type |
|----------|------------------------|---------------------|---------------|
| 1 | 70/0 | B | Braking |
| 2 | 0/irrelevant | A | Accelerating |
| | | B | Accelerating |

Table 8.O.7.3: Lorry speeds and positions

A - Maximum effect on centre beams

At least one wheel of every axle (left or right) passes the midspan of the middle centre beam (of the three instrumented centre beams) with a tolerance of 10 % of the span length.

B - Maximum effect on crossbeams

At least one wheel of every axle (left or right) passes the support of the middle centre beam (of the three instrumented centre beams – centre of crossbeam) with a tolerance of 10 % of the span length.

A – Test 1

The lorry shall have a speed of 70 (\pm 5) km/h and braking with a minimum deceleration of 4 m/s² is initiated at a distance between 10 and 5 m before the joint. The ABS system of the lorry shall be switched off. Further details of testing and lorry characteristics as 8.O.7.2.

B – Test 2

The lorry starts with the driven axle at a distance of 2 m before the joint and is brought to full acceleration. Further details of testing and lorry characteristics as 8.O.7.2.

8.O.8 Measurements and analyses

The following aspects shall be measured for further interpretation.

8.O.8.1 Lorry

1. Wheel print geometry (static). The dynamic wheel print length shall be derived from the strain gauge measurements of the centre beams in conjunction with the travelling speed (see below),
2. Tyre pressures,
3. Travelling speed (continuous, braking or accelerating),
4. Travelling position in transverse direction.

8.O.8.2 Expansion joint

Depending on the selection of instrumentation, the following shall be measured:

1. Centre beam width,
2. Gap width,
3. Strains (with gauge),
4. Accelerations,
5. Distance (with laser).

Interference effects and phase shifts between vertical, horizontal and rotation movements shall be filtered, prior to further analysis.

8.O.8.3 Over-rolling tests

8.O.8.3.1 Effects in the vertical plane

8.O.8.3.1.1 Initial dynamic impact factor

The vertical dynamic impact factor of the centre beam shall be derived from the vertical section moments. The section moments at the supports and midspan shall be derived from the section moments at the strain gauge locations, taking into account the transversely distributed load introduced by the wheel print and offsets, if relevant. The support and midspan moments shall be summed for the determination of the dynamic impact factors. The vertical dynamic impact factor daf for the considered velocity is the vertical moment interval (sum of support and midspan moments) for sequence "i" M_{Svi} , divided by the vertical moment interval for sequence 1 ($v = 0$) M_{Sv0} .

Analysis:

- Vertical support moment: M_{Sv} ,
- Vertical midspan moment: M_{mv} ,
- Vertical moment interval: $M_{Sv} = M_{Sv} + M_{mv}$,
- Vertical moment interval static: M_{Sv0} ,
- Vertical moment interval at sequence "i" with ($v \neq 0$): M_{Svi} ,
- Dynamic impact factor: $daf = M_{Svi}/M_{Sv0}$.

8.O.8.3.1.2 Upswing

Derive in the same way the vertical moment interval ($M_{Svu} = M_{Svu} + M_{mvu}$) after unloading.

The vertical Upswing ratio $Uv = M_{Svu}/M_{Sv}$

8.O.8.3.1.3 Combined dynamic vertical effect

The dynamic load (moment etc.) design interval ($E_{d,dyn}$) to be used for fatigue assessments shall be based on:

$$E_{d,dyn} = E_{dv0} \times daf \times (1 + Uv)$$

8.O.8.3.2 Effects in the horizontal plane

The horizontal transfer factor "tr" (including traction, "rolling friction" and dynamic impact effects) of the centre beam shall be derived from the horizontal section moments for a travelling lorry and the vertical section moments for a standing lorry. The section moments at the support and midspan shall be derived from the section moments at the strain gauge locations, taking into account the transversely distributed load introduced by the wheel print. The support and midspan moments shall be summed for the determination of the transfer factor. The transfer factor "tr" for the considered velocity is the measured horizontal moment interval for sequence "i" M_{Sh} , divided by the vertical M_{Sv0} .

Analysis:

- Vertical support moment for a static load: M_{sv0} ,
- Vertical midspan moment for a static load: M_{mv0} ,
- Vertical moment interval for a static load: $M_{sv0} = M_{sv0} + M_{mv0}$,
- Horizontal support moment for a moving load at velocity v : M_{shi} ,
- Horizontal midspan moment for a moving load at velocity v : M_{mhi} ,
- Horizontal moment interval for a moving load: $M_{shi} = M_{shi} + M_{mhi}$,
- Transfer factor V/H incl. daf: $tr = M_{shi}/M_{sv0}$.

8.O.8.3.3 Response ratio

Derive in the same way the vertical moment interval ($M_{svu} = M_{svu} + M_{mvu}$) after unloading.

The horizontal response ratio $U_h = M_{shu}/M_{sh}$.

Without further analyses U_h shall be taken as 1,0.

8.O.8.3.4 Combined dynamic vertical effect

The dynamic load (moment etc.) design interval ($E_{dh,dyn}$) to be used for fatigue assessments shall be based on:

$$E_{dh,dyn} = E_{dh0} \times daf \times (1 + U_h)$$

8.O.8.4 Braking and acceleration tests

Analyses of the braking and acceleration tests can be used for calibration purposes of the braking forces to be used for ULS and a more detailed approach of the horizontal load introduction at ULS.

8.O.8.4.1 Braking test

From the horizontal bending moments in the instrumented centre beams the horizontal load introduction can be derived. The "fictitious" horizontal spring stiffness of the joint can be derived from the horizontal load and the horizontal displacements.

8.O.8.4.2 Acceleration test

From the horizontal bending moments in the instrumented centre beams the horizontal load introduction can be derived. The "fictitious" horizontal spring stiffness of the joint can be derived from the horizontal load and the horizontal displacements.

8.O.8.4.3 Rotation effects

Based on an analysis, the rotation effects may not be relevant for specific types of Modular Expansion Joints. If not relevant (e.g. beam grid joints with welded connections between the centre beams and crossbeams), the measurements may be omitted.

The rotation effects shall be derived from displacement measurements.

8.O.9 Calculations

Parallel to the over-rolling test a calculation shall be carried out of the full-scale test expansion joint with a 3-D model.

8.O.9.1 Model

8.O.9.1.1 General

The overall dimensions of the model shall be such that all relevant frequencies and eigenvectors are found; therefore the model shall include the relevant features e.g. offsets, inflexion points (bends), cantilevering parts and deviating crossbeams. The model shall enable the calculation of the relevant section forces and bending moment at all cross sections with locations susceptible to fatigue; e.g. butt joint locations.

8.O.9.1.2 Centre beams

The centre beams shall at least be modelled with line elements with 6 degrees of freedom at each node. The mesh shall be such that natural frequencies can be calculated (this results in at least 4 elements per span for elements without intermediate nodes and at least 2 elements for elements with intermediate nodes).

8.O.9.1.3 Crossbeams

The cross beams shall at least be modelled with line elements with 6 degrees of freedom at each node. The mesh depends on the centre beams that are to be supported; each support is a node.

8.O.9.1.4 Connection centre beam – crossbeam

The modelling can be done in three ways: Constraint, dummy element or detailed mesh. The constraints have the risk of improper behaviour. The detailed mesh gives a relatively complicated mesh with many degrees of freedom to be analysed, not contributing to the objective of the analysis. The dummy element (line element connection with fictitious beam properties and, if relevant, dummy spring connections based on dynamic properties) is recommended.

8.O.9.1.5 Crossbeam support

The crossbeam supports shall be modelled with springs, simulating the combination of bearing and prestress element, based on the dynamic properties.

8.O.9.1.6 Damping

Damping is the decrease in vibrations caused by material damping and system damping.

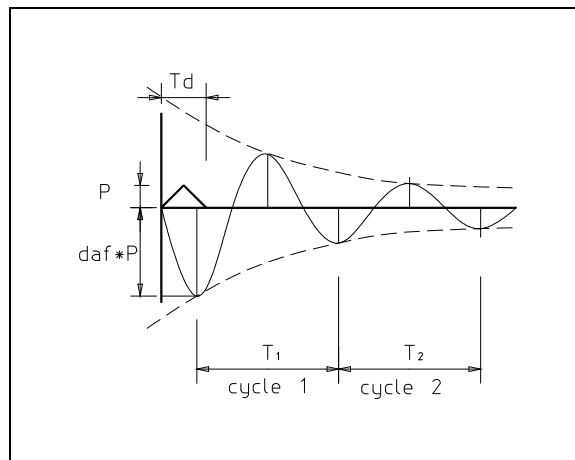


Figure 8.O.9.1.6: Cycles in structure with damped vibrations

The damping ratio for the calculation shall be based on the damping ratio found at measurements for the relevant cross sections $d = C/C_{cr}$

$$A_{n+1} = A_n * \frac{1}{e^{2fd}}$$

in which:

A_n = Amplitude "n"

$d = C/C_{cr}$

Example of d:

Steel: $d = 0,005$

Concrete: $d = 0,010$

In expansion joints "d" often is taken as 0,1 for the complete system

The respective components such as centre beams or cross beams can have different damping ratios.

8.O.9.2 Cantilevers etc.

Cantilevering parts greater than 0,3 times the centre beam span shall be analysed separately by calculation and shall fulfil the following requirement:

- Stress intervals below constant amplitude criterion $\Delta\sigma_D$

The stress intervals shall be derived from the deformed structure under quasi static loads which are to be applied as mass vibration. The damping ratio for the analysis shall be taken as the material damping only.

8.O.9.3 Loads

The axle loads of the test vehicle shall be modelled as time history loads, giving due consideration to the dynamic wheel print geometry derived from the over-rolling test.

Centre beam loading times are derived from the sum of the wheel print length and the centre beam width.

Crossbeam loading times depend on the wheel print length, the number of centre beams (widths) and the number of gaps (widths).

8.O.9.4 Calculation results

The eigenfrequencies and eigenvectors shall be calculated. The results shall be compared with the measured eigenfrequencies and eigenvectors that can be derived from the measurements.

Note: The full-scale test results only allow the derivation of the natural frequencies, whereas the model allows the derivation of natural frequencies and 2nd harmonics. Further small deviations in geometry can give rise to differences between the measurements and the model calculations.

If the model results do not deviate more than 10 %, no further action has to be taken. If the results deviate more than 10 %, additional analyses are needed for a better adjustment, or modifications of the model.

Note: No response calculations need to be carried out.

8.O.9.5 Combination of effects

Without further analyses the dynamic stress intervals from vertical loads shall be combined with the dynamic stress intervals from horizontal loads.

For stresses at a specific location from both load effects into the same direction applies:

$$\Delta\sigma_{\text{comb}} = \Delta\sigma_v + \Delta\sigma_h$$

$$\Delta\sigma_{\text{comb}} = \text{combined stress interval}$$

If needed, the combined stress interval may include the phase shift between vertical and horizontal vibrations, based on additional analyses.

8.O.9 Test report

The test report shall comprise:

- Description of the joint, including the adjacent pavement over 30 m before and after the joint, slopes in traffic direction and perpendicular to the traffic direction;
- Drawing of the joint (dimensions, dimensions of components, material specifications etc.);
- Test lorry (configuration and static wheel loads, wheel print dimensions, inflation pressure of tyres, wheel and axle distances, position relative to the joint in transverse direction during over-rolling, over-rolling speed);
- Measuring devices (types) and their locations (detailed sketches, related to the joint dimensions);
- Sampling frequency of measuring devices (accelerometers and strain gauges);
- Eigenfrequencies and eigenvectors (V, H, T);
- Dynamic amplification daf factor (V);
- Transfer effects incl. dynamic amplification factor (V-H);
- Deflections;
- Internal forces and moments;
- Damping (V + H);
- Upswing effect V, and response effect H;
- Date of test execution (environmental aspects: air temperature etc.).

8.O.10 Use of the results

The effect of ageing of components shall be considered, if relevant.

The dynamic amplification factors and the transfer factors can be traffic velocity dependent and the most adverse values shall be used for further (quasi static) analyses of the joint.

Annex 8P

typical designs of modular expansion joints

Note: The purpose of this annex is to identify the different types of Modular Expansion Joints which are covered by Part 8. The sketches are examples.

Table with explanatory key

| Number | Part/component |
|--------|--------------------|
| 1 | Edge beam |
| 2 | Centre beam |
| 3 | Seal element |
| 4 | Control element |
| 5 | Joist box |
| 6 | Prestress element |
| 7 | Bearing |
| 8 | Stirrup |
| 9 | Crossbeam |
| 10 | Cover plate |
| 11 | Footpath crossbeam |
| 12 | Guide crossbeam |

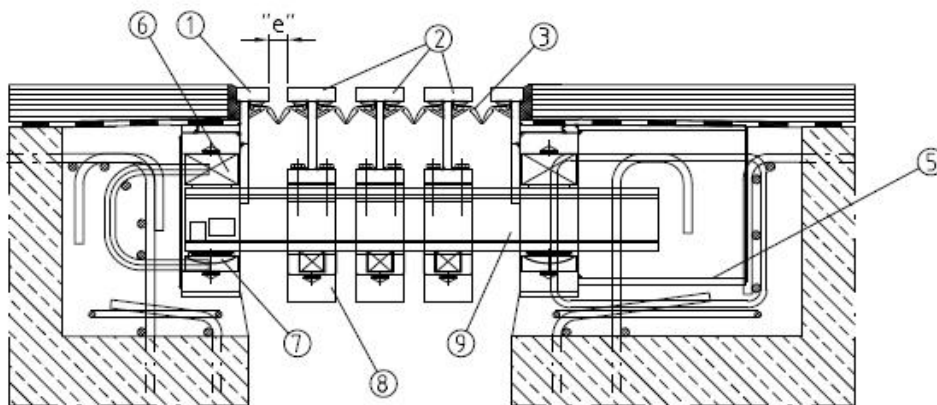


Figure 8.P.1: Cross section at carriageway with crossbeam of single crossbeam modular joint with shear control elements between centre beams

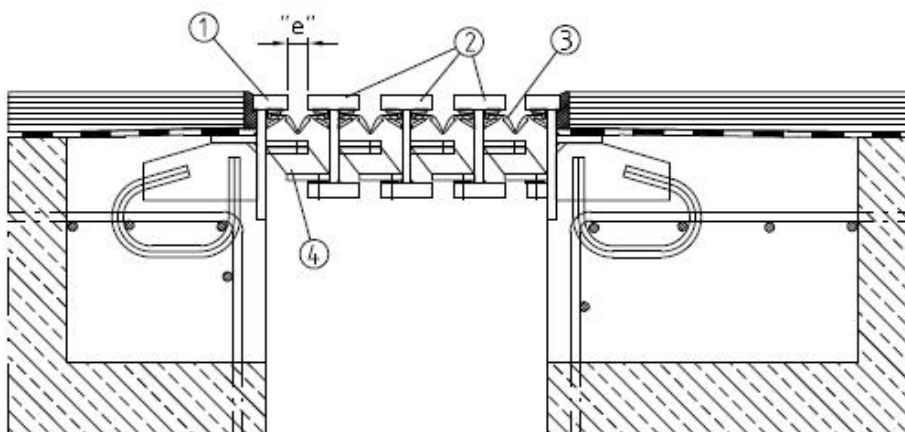


Figure 8.P.2: Cross section at carriageway between crossbeams of single crossbeam modular joint with shear control elements between centre beams

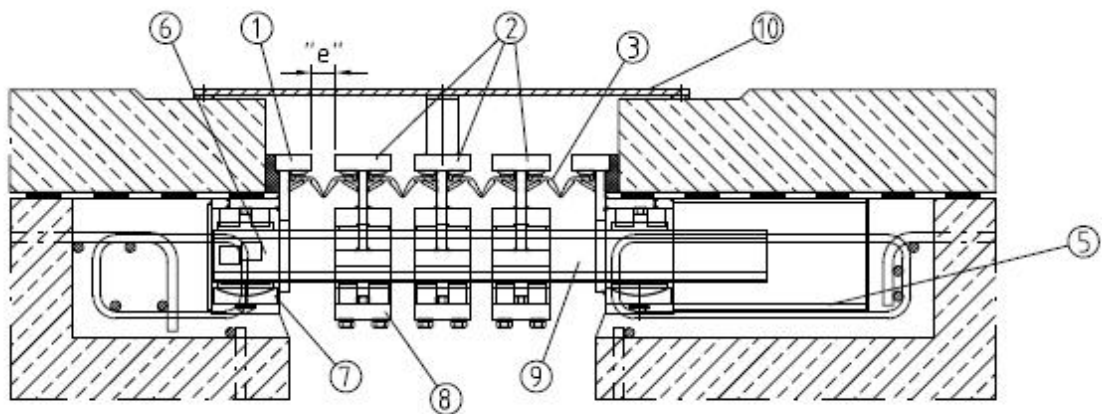


Figure 8.P.3: Cross section at footpath with crossbeam of single crossbeam modular joint with shear control elements between centre beams and cover plate

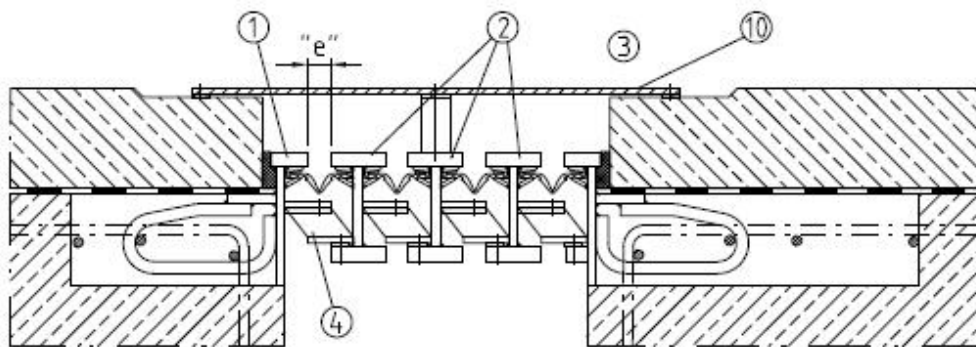


Figure 8.P.4: Cross section at footpath between crossbeams of single crossbeam modular joint with shear control elements between centre beams and cover plate

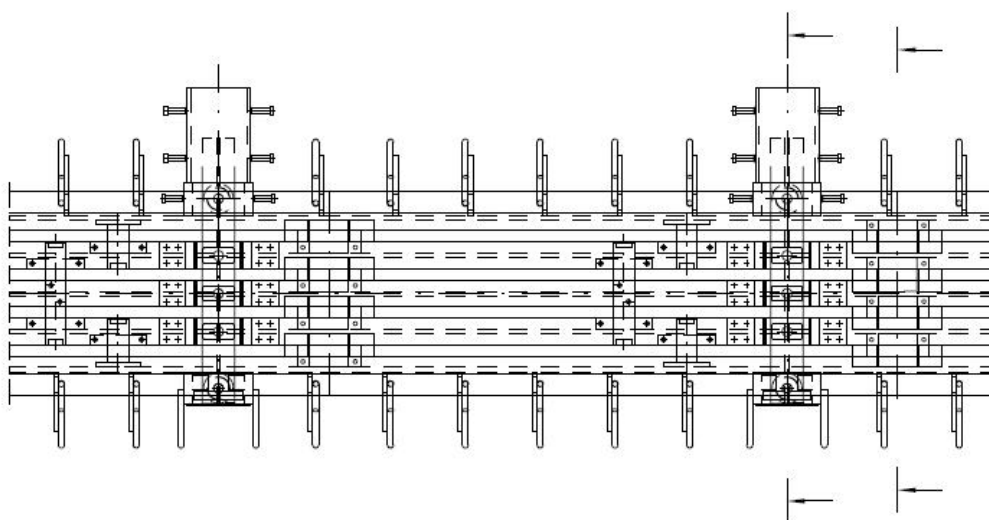


Figure 8.P.5: Plan view at carriageway of single crossbeam modular joint with shear control elements between centre beams

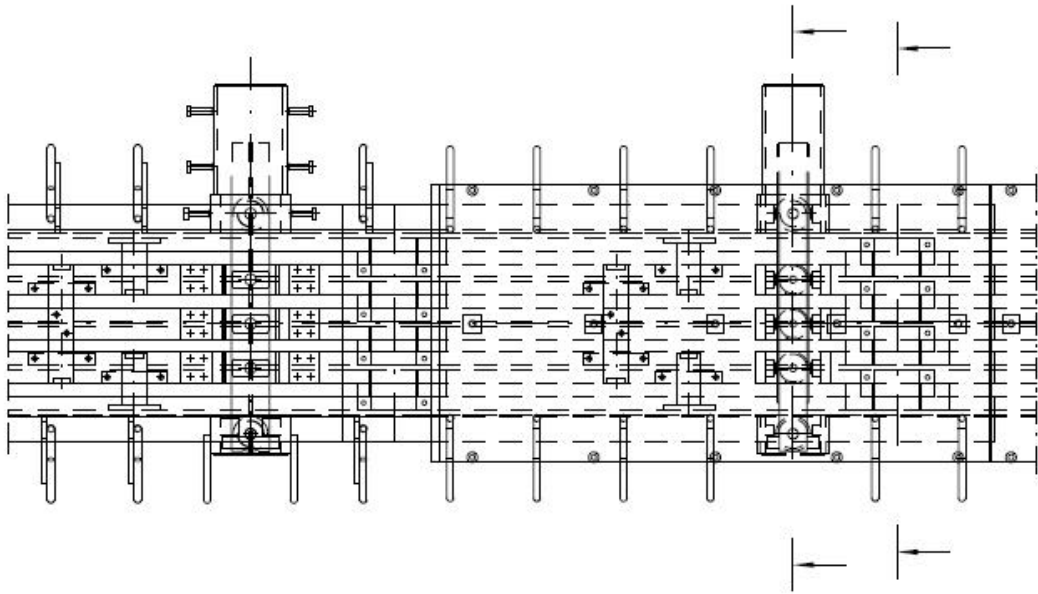


Figure 8.P.6: Plan view at carriageway and footpath of single crossbeam modular joint with shear control elements between centre beams

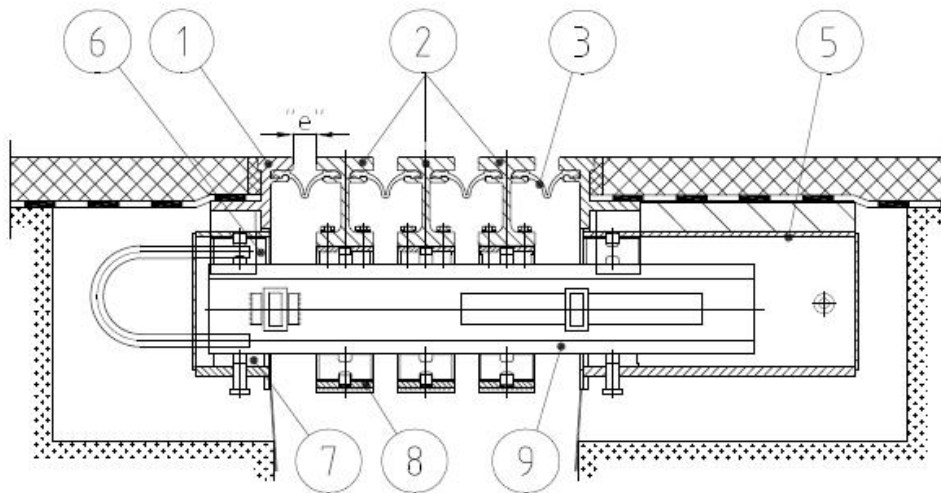


Figure 8.P.7: Cross section at carriageway with crossbeam of single crossbeam modular joint with shear control elements under centre beams

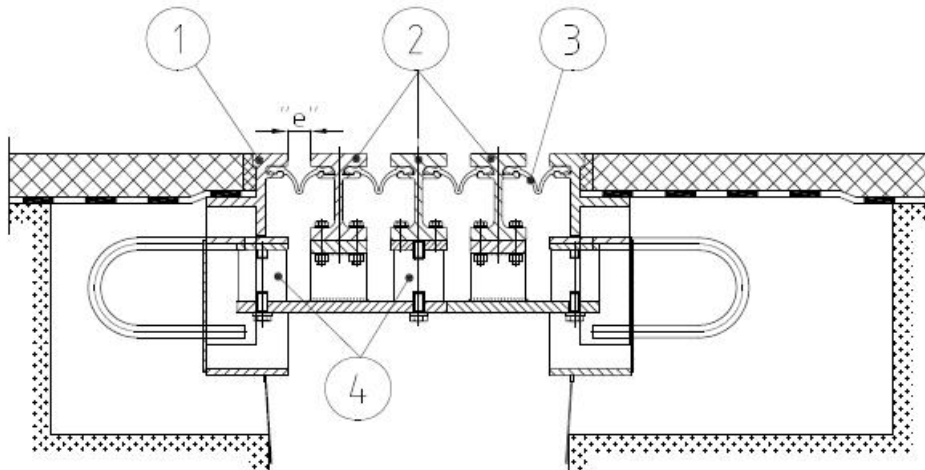


Figure 8.P.8: Cross section at carriageway between crossbeams of single crossbeam modular joint with shear control elements under centre beams

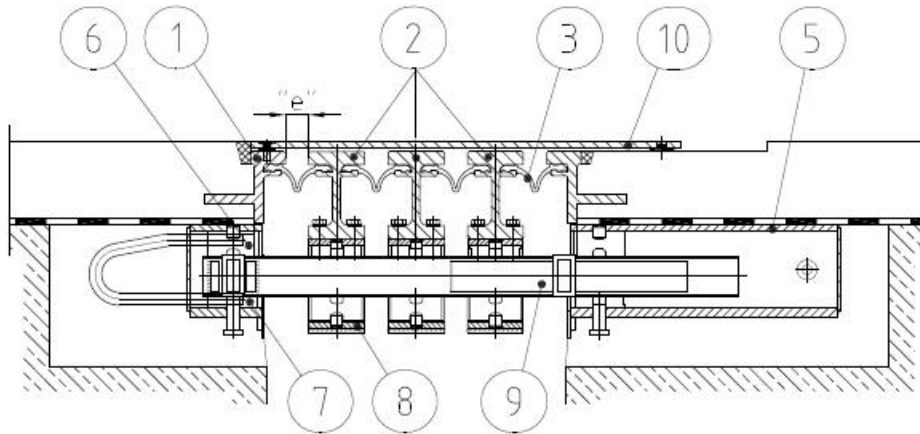


Figure 8.P.9: Cross section at footpath with crossbeam of single crossbeam modular joint with shear control elements under centre beams and cover plate

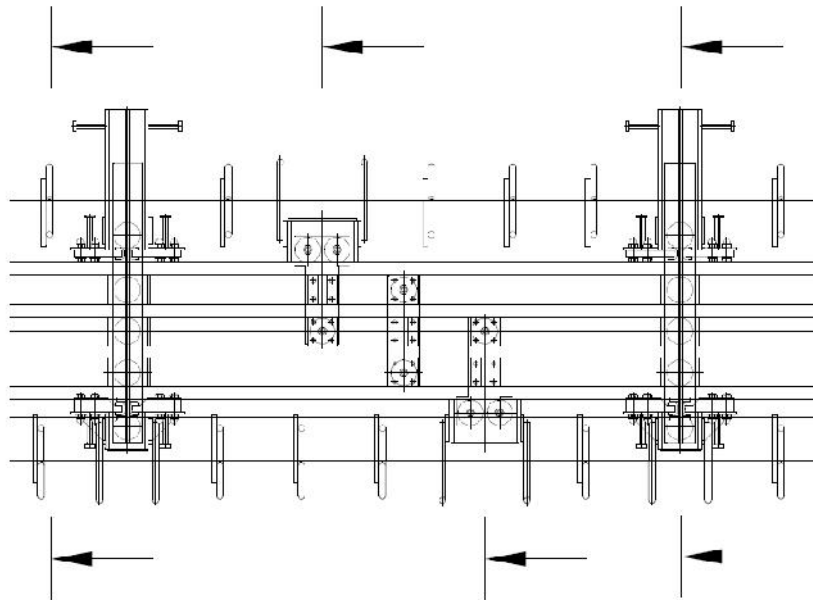


Figure 8.P.10: Plan view at carriageway of single crossbeam modular joint with shear control elements under centre beams

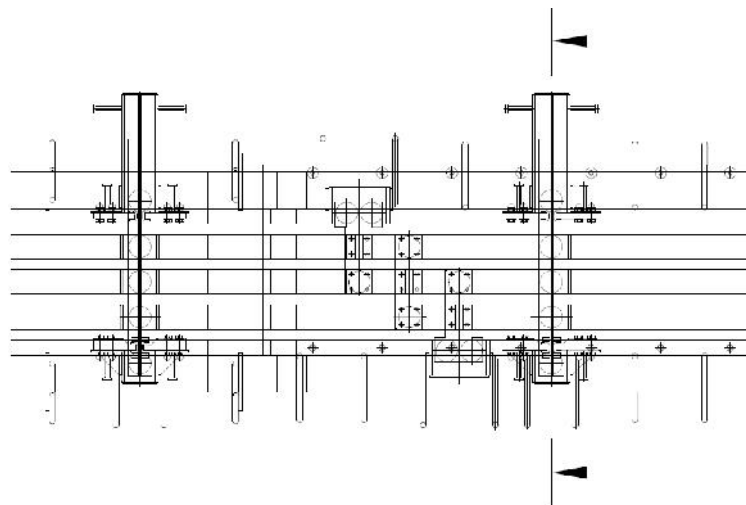


Figure 8.P.11: Plan view at carriageway and footpath of single crossbeam modular joint with shear control elements under centre beams

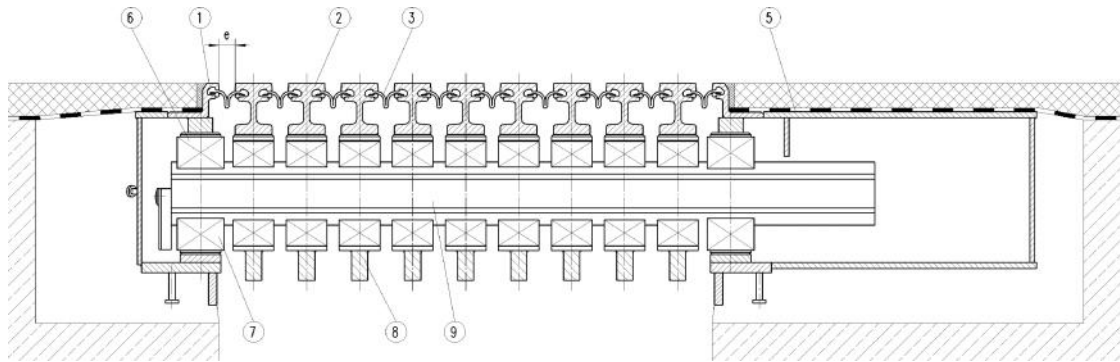
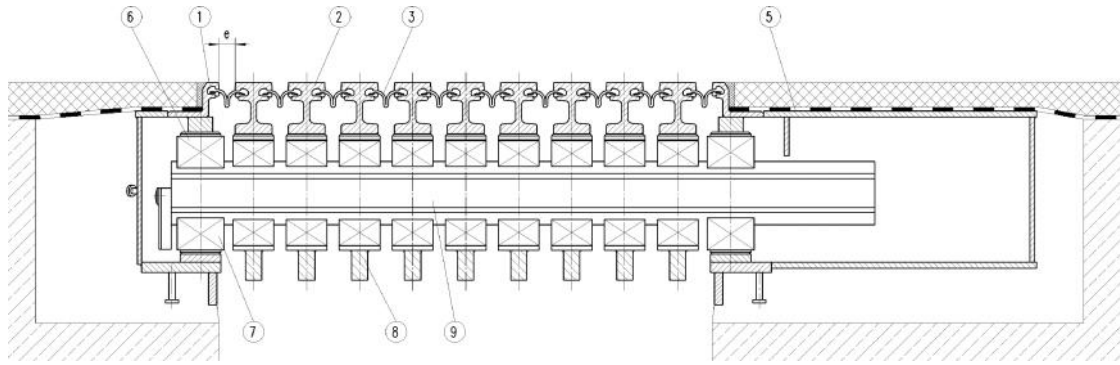


Figure 8.P.12: Cross section at carriageway with crossbeam of single crossbeam modular joint with kinematic guidance

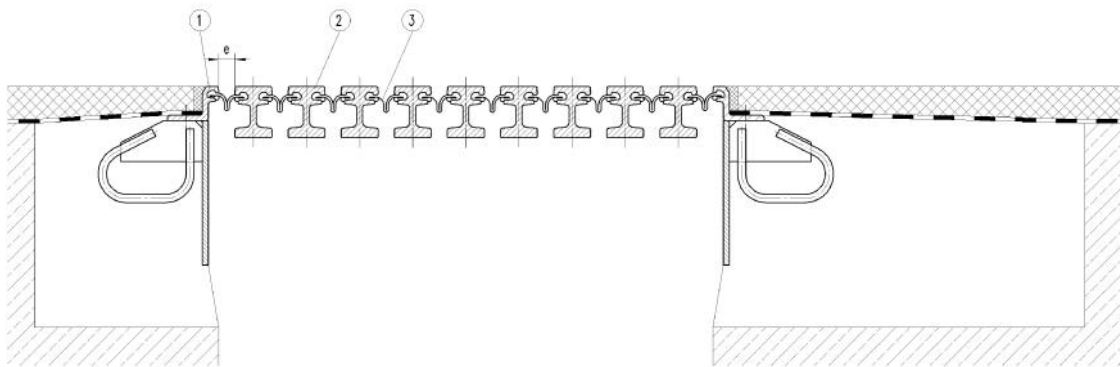


Figure 8.P.13: Cross section at carriageway between crossbeams of single crossbeam modular joint with kinematic guidance

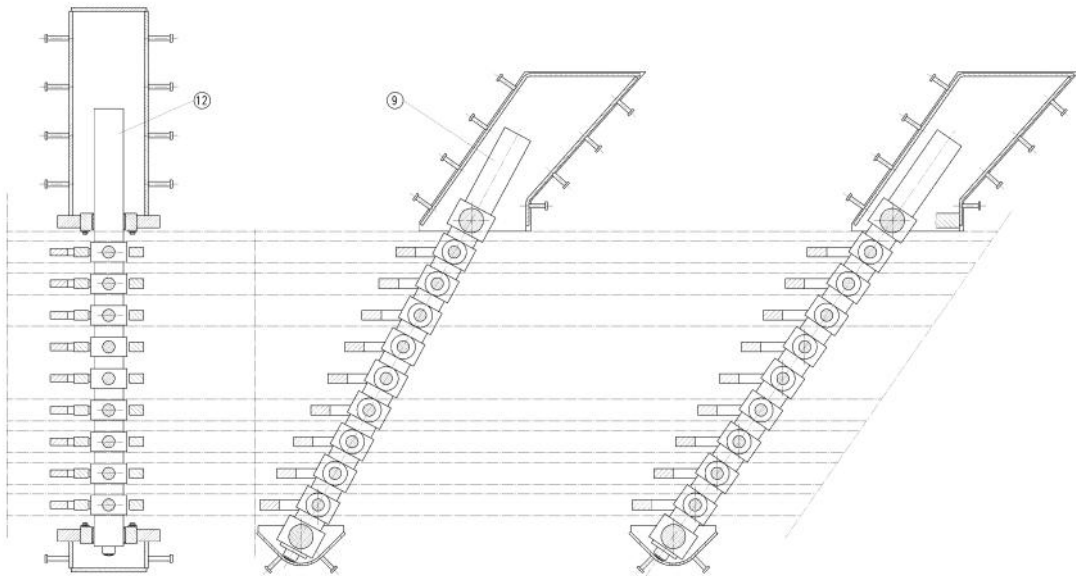


Figure 8.P.14: Plan view at carriageway and footpath of single crossbeam modular joint with kinematic guidance

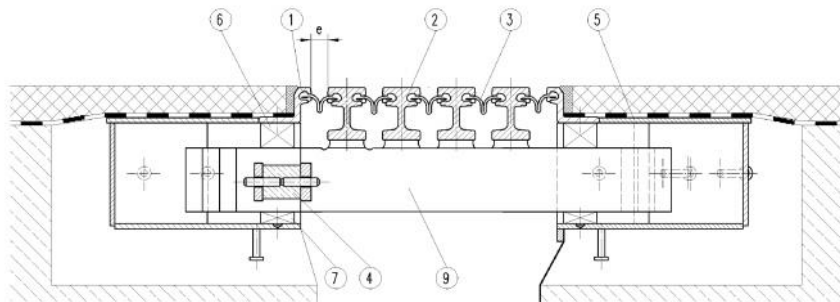


Figure 8.P.15a: Cross section at carriageway with crossbeam of multiple crossbeam modular joint with compression control elements

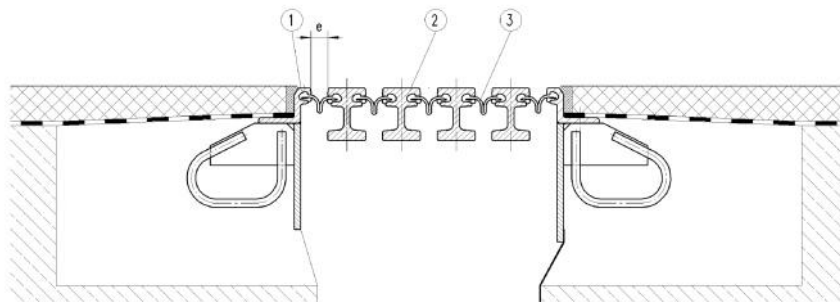


Figure 8.P.15b: Cross section between crossbeams of multiple crossbeam modular joint with compression control elements at carriageway.

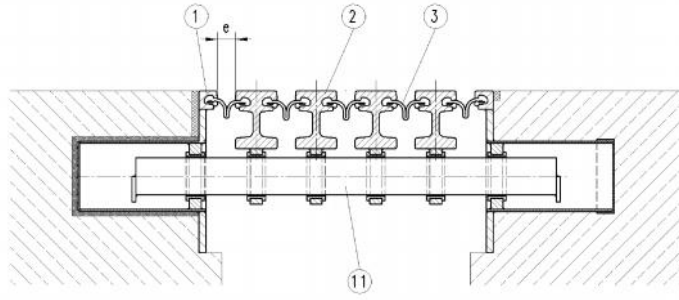


Figure 8.P.16 Cross section at footpath with crossbeam of multiple crossbeam modular joint with compression control elements

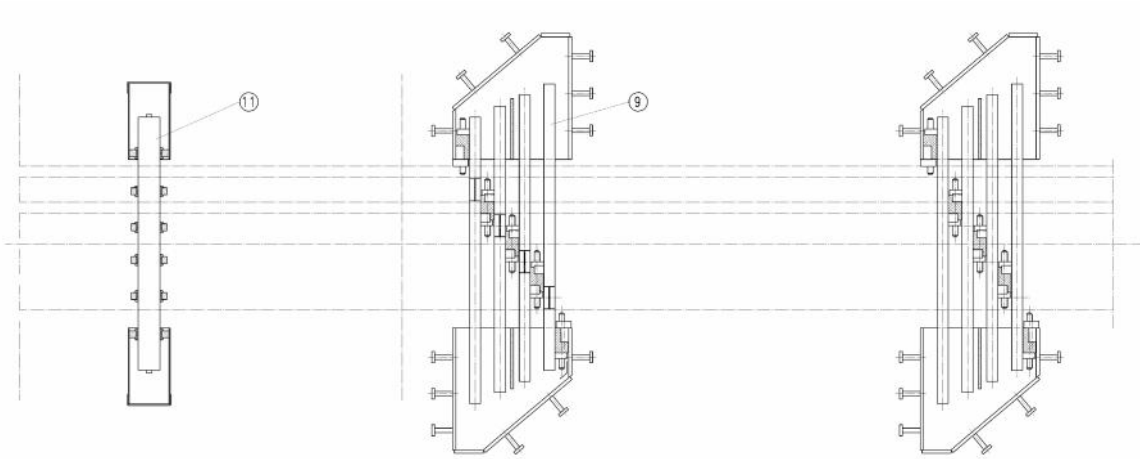


Figure 8.P.17: Plan view at carriageway and footpath of multiple crossbeam modular joint with compression control elements