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ETAG n° 032
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GUIDELINE FOR
EUROPEAN TECHNICAL APPROVAL
of
EXPANSION JOINTS FOR ROAD BRIDGES
PART 3: FLEXIBLE PLUG EXPANSION JOINTS

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FOREWORD

See Part 1 of this ETAG N° 032.

REFERENCE DOCUMENTS

See Part 1 of this ETAG N° 032.

Specific standards of this family part

Standards	Clause	Titles
EN 932-3	Table 5.2, 3P.2.1	Test for general properties of aggregates – Part 3: Procedure and terminology for simplified petrographic description
EN 933-1 and 2	Table 5.2 and 8.3A, 3P.2.2	Test for geometrical properties of aggregates – Part 1: Determination of particle size distribution – Granulometric analysis, Sieving method Part 2: Determination of particle size distribution – Test sieves, nominal size of apertures using the hand-sieving method by means of dry sieving
EN 933-3	Table 5.2 and 8.3A	Part 3: Determination of particle shape – Flakiness index
EN 933-4	Table 5.2 and 8.3A, 3P.2.5	Part 4: Determination of particle shape – Shape index
EN 1097-2	Table 5.2, 3P.2.6	Tests for mechanical and physical properties of aggregates – Part 2: Method for the determination of the strength to fragmentation
EN 1097-3	Table 5.2, 3P.2.4	Tests for mechanical and physical properties of aggregates – Part 3: Determination of loose bulk density and voids
EN 1097-6	Table 5.2, 3P.2.3	Tests for mechanical and physical properties of aggregates – Part 6: Determination of the real density and of coefficient of water absorption
EN 1367-5	Table 5.2, 3P.2.7	Tests for thermal and weathering properties of aggregates – Part 5: Determination of resistance to thermal shock
EN 1427	Table 5.2 and 8.3A, 3P.1.3	Determination of softening point – Ring and ball method
EN 1991-2	4.1.1.2.1, 3Q	Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges
EN 1993	5.1.1.2.1	Eurocode 3: Design of steel structures
EN 1999	5.1.1.2.1	Eurocode 9: Design of aluminium structures
EN 10025	Table 5.2	Hot rolled products of structural steels
EN 12607-1	3P.1.6	Bitumen and bituminous binders – Determination of the resistance to hardening under influence of heat and air – Part 1: RTFOT method
EN 12607-3	Table 5.2, 3P.1.6	Bitumen and bituminous binders – Determination of the resistance to hardening under influence of heat and air – Part 3: RFT method
EN 12697-1	3P.1.10.1	Bituminous mixtures – Test methods for hot mix asphalt – Part 1: Soluble binder content
EN 12697-8	Table 5.2, 3P.3.2	Bituminous mixtures – Test methods for hot mix asphalt – Part 8: Determination of void characteristics of bituminous specimens
EN 12697-22	Table 5.2, 3P.3.3	Bituminous mixtures – Test methods for hot mix asphalt – Part 22: Wheel tracking

EN 12697-23	Table 5.2, 3P.3.1	Bituminous mixtures – Test methods for hot mix asphalt – Part 23: Determination of the indirect tensile strength of bituminous specimens
EN 12697-39	3-P.1.10.2	Bituminous mixtures – Test methods for hot mix asphalt – Part 39: Binder content by ignition
EN 13043	3-P.2.2	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
EN 13398	Table 5.2 and 8.3A, 3P.1.4	Bitumen and bituminous binders – Determination of the elastic recovery of modified bitumen
EN 13589	Table 5.2, 3P.1.5, 3P.1.12	Bitumen and bituminous binders – Determination of the tensile properties of modified bitumen by the force ductility method
EN 13702	3P.1.7	Determination of dynamic viscosity of modified bitumen – Part 1: Cone and plate method and Part 2: Coaxial cylinders method
EN 13880-2	Table 8.3A, 3P.1.2	Hot applied joint sealants – Part 2: Test method for the determination of the cone penetration at 25 °C
EN 13880-3	Table 5.2 and 8.3A, 3P.1.4, 3P.1.2	Hot applied joint sealants – Part 3: Test method for the determination of penetration and recovery (resilience)
EN 13880-5	Table 5.2 and 8.3A, 3P.1.9	Hot applied joint sealants – Part 5: Test method for the determination of flow length
EN 14188-4	Table 5.2	Joint fillers and sealants – Part 4: Specifications for primers to be used with joint sealants
EN 14770	3-P.1.8	Bitumen and bituminous binders – Determination of complex shear modulus and phase angle – Dynamic Shear Rheometer (DSR)
EN 15326	3P.1.2	Bitumen and bituminous binders – Measurement of density and specific gravity – Capillary-stoppered pyknometer method
ISO 3310	3-P.1.10	Test sieves – Technical requirements and testing
ISO 3838	Table 5.2 and 8.3A, 3P.1.2	Determination of density by Capillary-Stopped Pyknometer
ISO 6721-1	3-P.18	Plastics – Determination of dynamic mechanical properties – General principles

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.

2. SCOPE

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").

2.1 SCOPE

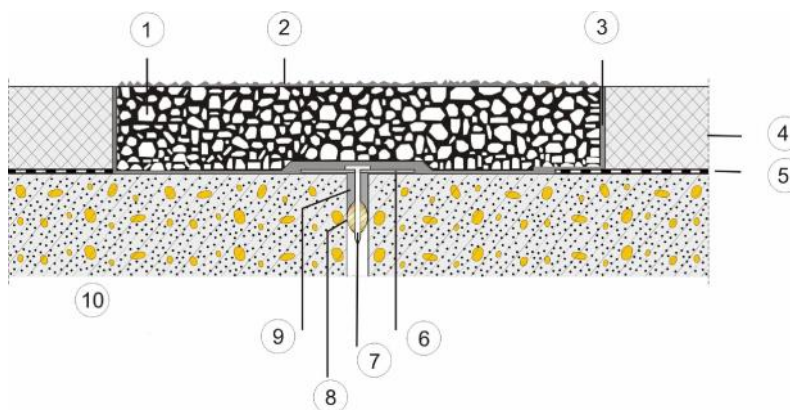
2.1.1 General

This Part of ETAG N° 032 specifies the product performance characteristics, methods of verification and assessment procedures for Flexible Plug Expansion Joints (FPEJ) for road bridges to ensure the fitness for use of the products for intended use. Further, see Part 1 of this ETAG N° 032.

2.1.2 Definitions

The definition for Flexible Plug Expansion Joint (FPEJ) given in Part 1, 2.1.2.2 applies. The following definition details the general definition given in 2.1.2.2 of Part 1. The binders used in a joint filling mixture are based on bituminous mixture (these are referred to as "conventional materials").

Examples of design of flexible plug expansion joint are shown in the Figure 1.



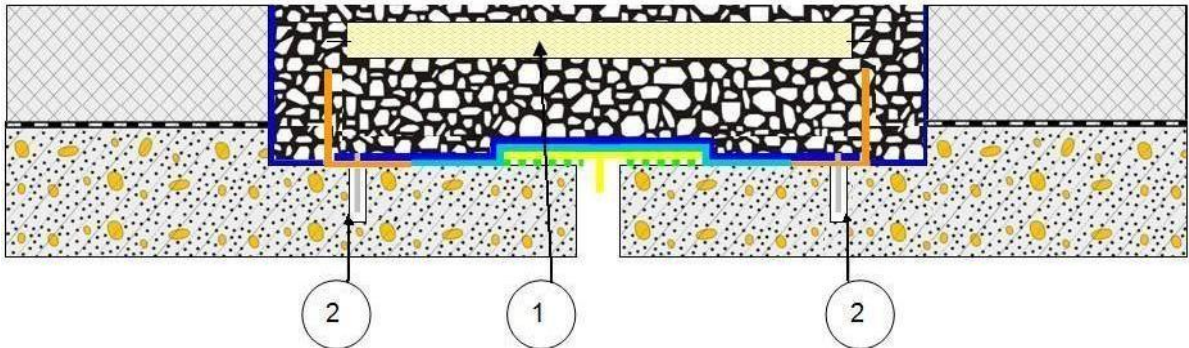
Key

- | | |
|--|--------------------|
| 1 - Joint filling mixture (binder, aggregate), | 6 - Plate, |
| 2 - Surface dressing, | 7 - Fixing, |
| 3 - Tanking, | 8 - Caulking, |
| 4 - Pavement*, | 9 - Sealant, |
| 5 - Bridge deck waterproofing*, | 10 - Bridge deck*. |
- * Not part of the kit

Figure 1a: Cross section of a typical flexible plug expansion joint

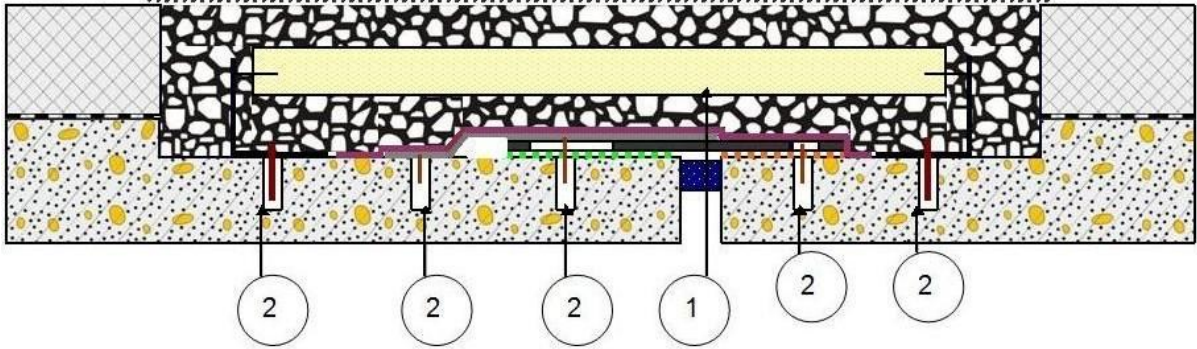
This picture (Figure 1a) shows methods of joining waterproofing layer with the joint filling mixture (butt joint and overlap joint arrangements).

Note: As a schematic illustration this figure does not cover all possible system designs.



Key
 1 – Movement aid
 2 – Anchorage system

Figure 1b: Cross section of a typical flexible plug expansion joint showing movement aids with anchorage



Key
 1 – Movement aid
 2 – Anchorage system

Figure 1c: Cross section of a typical flexible plug expansion joint showing movement aids and plate anchorage system

Note: Schematic illustrations. These figures do not cover all possible system designs.

2.2 USE CATEGORY AND KITS

See Part 1 of this ETAG N° 032.

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.

The manufacturer shall declare the operating temperature range of the product according to the levels as stated in Part 1 of this ETAG N° 032.

Testing methods described in this Part of the ETAG generally cover the operating temperature range -20 °C to +45 °C.

For Flexible Plug Expansion Joints used outside this temperature range, it shall be assessed whether the materials show changes of their properties in the concerned range of temperature. In this case, these effects shall be considered in the approval procedure.

2.3.3 Installation

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

2.3.4 Working life

See Part 1 of this ETAG N° 032.

The working life category for Flexible Plug Expansion Joints (FPEJ) shall be selected from the table of Working Life Categories as stated in Part 1 of this ETAG N° 032.

It is assumed that a Flexible Plug Expansion Joint is suitable for the working life category 1 (10 years) when it is tested according to the procedures stated in Chapter 5 and assessed according to Chapter 6, as meeting the requirements stated in Chapter 4 of this ETAG Part.

Note: For other working life categories according to ETAG N° 032 Part 1, for requested supplementary verifications, clause 9.2 of the CPD applies.

For this family Part, there are no component which are replaceable.

It is likely that the Working Life of the Flexible Plug Expansion Joint is influenced by the following:

- Adjacent pavement,
- Traffic behaviour (including stationary, rolling, queuing traffic),
- Temperature,
- Slope of pavement.

The aspects stated above have to be given in the ETA in conjunction with an indication about the assumed working life.

3. TERMINOLOGY

3.1 COMMON TERMINOLOGY AND ABBREVIATIONS

See 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.

Aggregate	A hard durable crushed mineral rock of certain particle size (for example a single sized aggregate) used to form the skeletal structure of the joint filling mixture
Binder	A flexible material which fills the voids created in the packed aggregate layers of the joint
Caulking	A backing material which is placed in the structural gap to provide support for sealant in an expansion joint
Debonding strip	A thin sheet of flexible material laid over the plate preventing adhesion between binder and plate
Drainage channel	A pipe or tube located in a horizontal plane at the base of the trench adjacent to the waterproofing layer for the collection and channelling of the water away from the bridge deck gap and bearing shelf
Filled bituminous material	A compound of bitumen and mineral filler, used as a binder, in a FPEJ. The bitumen may be modified with additives
Fixing	A means of locating a component of the expansion joint to the bridge structure
Joint filling mixture	A solid mass made up of a mixture of binder and aggregates providing a strong waterproof and traffic resistant filling for the joint trench
Kerb detail	The arrangement of the expansion joint where the road carriageway and footway intersect
Movement aids	Additional component which are incorporated in the joint to improve performance
Plate	A thin plate of metal (or other suitable material) which bridges over the bridge deck gap and prevents ingress of aggregate into the bridge deck gap
Primer	A liquid used to pre-treat a surface for the purpose of improving adhesion
Sealant	A flexible material poured into a bridge deck gap for the purpose of sealing that joint
Surface dressing	Application of small sized aggregate to provide texture and skid resistance to the surface of a Flexible Plug Expansion Joint
Trench (joint recess)	A regular opening cut or formed in the road surface symmetrically over the bridge deck gap to contain the FPEJ system
Tanking	A precoat layer applied to the internal surfaces of the trench for the purpose of improving adhesion between the filling mixture and sealing the internal faces of the trench
Vertical face	The vertical cut face of the asphalt surfacing which is the interface between the Flexible Plug Expansion Joint and the adjacent surfacing

3.2.2 Abbreviations

See Part 1 of this ETAG N° 032.

SECTION TWO: GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

GENERAL NOTES

See Part 1 of this ETAG N° 032.

4. REQUIREMENTS

For 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 ROAD BRIDGE EXPANSION JOINT PERFORMANCE

Comprehensive table

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

4.1 KITS

4.1.1 Mechanical resistance and stability

4.1.1.1 General

See Part 1 of this ETAG N° 032.

The mechanical resistance of the kit depends mainly on the bridging plate behaviour in the usual range of temperature. Therefore the mechanical resistance of the binder and filler materials in the ULS condition is considered not relevant.

The specific Limit State requirements for this product family are defined in Table 4.1.1.

Table 4.1.1: Limit state and assessment criteria definition

Limit State	Limit State requirements	Remark
ULS	No collapse of bridging plate.	
SLS	No permanent deformation greater than permitted (see 4.1.1.2, 4.1.1.3 and 4.1.4). No permanent deformation of bridging plate. No cracking at the surface of width more than 1 mm and depth more than 5 mm or debonding of filling mixture.	Only reversible deformations, displacement or rotation. Allowance of creep or hysteresis effect.

For 4.1.1.2 and 4.1.1.3, actions for "Mechanical resistance and stability" as well as "Fatigue" derive from Annex G of Part 1. The verification methods are described in Annexes 3-N and 3-M of this family Part.

4.1.1.2 Mechanical resistance

4.1.1.2.1 General

See Part 1 of this ETAG N° 032 and the Table 4.1.1 of this Part.

Calculation of loads refers to Annex 3-Q of this Part.

The static load model LM1, TS1, in Annex G.2, shall be used.

Load conditions as relevant to Flexible Plug Expansion Joint and their required performance are represented by the following formulas.

Expansion joint parameters (Part 1, Figure G2 and Table G2):

$$L_j(\text{fpej}) \leq 0,5 \text{ m}; W_j(\text{fpej}) \leq 1,2 \text{ m}; Q_{1k} = 300 \text{ kN}$$

4.1.1.2.2 ULS requirement

At ULS, the requirement for FPEJ type products is that the bridging plate shall not collapse.

At ULS the design situation is given by:

$$C_{ULS} = \psi_{0T} \gamma_{Q1} Q_{1k} + \psi_{0d} \gamma_{dE} d_{Ek} \quad [\text{EQ. 4.1}]$$

Where:

Q_{1k} = Axle load

γ_{Q1} = Partial factor traffic loads

ψ_{0T} = Combination factor for traffic loads

ψ_{0d} = Combination factor for opening position

d_{Ek} = Maximum manufacturer declared opening position of the joint

Design situation C_{ULS1} :

$$C_{ULS1}: Q_{1d} = 405 \text{ kN with } 60 \% \text{ of manufacturer's declared opening } (d_{Ek})$$

Design situation C_{ULS2} :

$$C_{ULS2}: Q_{1d} = 284 \text{ kN with full manufacturer's declared opening } (d_{Ek})$$

Design contact pressure:

$$\text{contact, ULS} = \gamma_{Q1} [(Q_{1k} / 2) \times (1/\text{contact area})] \quad [\text{EQ. 4.2}]$$

$$\text{contact (at surface)} = 1,35 \text{ N mm}^{-2}$$

This design contact pressure shall be reduced at the bridging plate with the application of the dispersal effect (D) in accordance with EN 1991-2, 4.3.6.

4.1.1.2.3 SLS requirement

At SLS, the requirement for Flexible Plug Expansion Joint type products is that there shall be:

- no permanent deformation of the joint surface greater than permitted,
- no permanent deformation of the bridging plate,
- no cracking or debonding of filling mixture.

At SLS the design situation is given by:

$$C_{SLS} = \psi_{0T} Q_{1k} + \psi_{0d} d_{Ek} \quad [EQ. 4.3]$$

Where:

Q_{1k} = Axle load

ψ_{0T} = Combination factor for traffic loads

ψ_{0d} = Combination factor for opening position

d_{Ek} = Maximum manufacturer declared opening position of the joint

Design situation C_{SLS1} :

$$C_{SLS1}: Q_{1d} = 300 \text{ kN with full manufacturer's declared opening } (d_{Ek})$$

Contact pressure (SLS)

$$\text{contact, SLS} = [(Q_{1k} / 2) \times (1/\text{contact area})] \quad [EQ. 4.4]$$

$$\text{contact (at surface)} = 1,00 \text{ N mm}^{-2}$$

Note: The horizontal loads are not taken into account.

4.1.1.3 Resistance to fatigue

See Part 1 of this ETAG N° 032 and Table 4.1.1 of this family Part.

Resistance to fatigue for Flexible Plug Expansion Joint shall be demonstrated by testing for repeated loading and repeated movement, as stated below:

- Repeated loading by vehicle wheels which typically would lead to deformation or wheel rutting, taking into account dynamic loading by traffic.
- Loading of the structure resulting in fast movements at the expansion gap which have to be accommodated by the expansion joint (see 4.1.1.5. of this Part).

The expansion joint shall withstand the action of dynamic repeated loading of traffic and show no significant deformation or cracking within the limits of tolerance as stated in Chapter 5 (Verification). Contact pressure is derived from Annex 3-Q, Table 3.Q-3.

Combination for fatigue limit state:

$$C_{FAT} = Q_{1k, \text{fat}} + \psi_{0d} d_{Ek} \quad [EQ. 4.5]$$

Where:

$\psi_{0d} = 0,6$ Combination factor

d_{Ek} = Maximum declared opening position of the joint

$C_{FAT}: Q_{1k, \text{fat}} = 146 \text{ kN with } 60 \% \text{ of manufacturers declared opening position of the joint}$

Contact pressure (FAT)

$$\text{contact, fat} = [(Q_{1k, \text{fat}} / 2) \times (1/\text{contact area})] \quad [EQ. 4.6]$$

$$\text{contact, fat (at surface)} = 0,49 \text{ N mm}^{-2}$$

$Q_{1k, \text{fat}}$ are axle loads in relation to the number of vehicles for the fatigue load model considered. The number of vehicles (N_{obs}) shall be in accordance with the EN 1991-2 and Part 1 of this ETAG N° 032.

Resistance to fatigue in the context of Flexible Plug Expansion Joint is not treated as fatigue in the classic sense of, for example, mechanical behaviour of metals used in mechanical joints. This is because the materials typically used in the construction of Flexible Plug Expansion Joint behave in a different manner to metals. This information has to be stated in the ETA.

4.1.1.4 Seismic behaviour

No requirement. Table 4.1.1.4 in Part 1 of this ETAG N° 032 is not applicable.

Note: It is anticipated that a Flexible Plug Expansion Joint should be subject to actions resulting from seismic activity which cause movements to occur outside of the design capability, then the joint would require to be repaired or replaced.

4.1.1.5 Movement capacity

The movement capacity shall be declared by the manufacturer.

The capacity shall be assessed according to verification method in Chapter 5.

Minimum clearance, as described in Part 1 of this ETAG N° 032, is not relevant.

It is a characteristic of Flexible Plug Expansion Joints that as the structure expands and contracts it generates tension or compression in the filling material of the joint. This results in large but slowly occurring movements mainly resulting from seasonal temperature changes and relatively small but often repeated movements induced by the traffic. The filling material shall be able to sustain these loading effects without restricting its function as well as not causing detrimental effects on the structure and surrounding surfacing material.

The nominal movement capacity of an expansion joint is the ability to allow movement at the bridge deck (structure) gap resulting from displacement of the main structure under unloaded and loaded conditions.

4.1.1.6 Cleanability

Not relevant for this family Part.

Note: Flexible Plug Expansion Joints are generally regarded to be flush to the surface and to have no surface discontinuities.

4.1.1.7 Resistance to wear

See Part 1 of this ETAG N° 032.

If the kit contains component(s) subject to wear according to Part 1, this shall not lead to de-bonding and/or cracking (see Table 4.1.1).

4.1.1.8 Watertightness

See Part 1 of this ETAG N° 032 without the alternative of a sub surface drainage system.

4.1.2 Safety in case of fire

According to Part 1: 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

Not relevant for this family Part.

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.

4.1.4.3 Drainage capacity

Not relevant for this family Part.

4.1.5 Protection against noise

According to Part 1: Not relevant.

4.1.6 Energy economy and heat retention

According to Part 1: 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

See Part 1 of this ETAG N° 032.

The aspects related to the durability of a Flexible Plug Expansion Joint for Road Bridges, and which shall be taken into account, are:

- a) Corrosion. See Part 1 of this ETAG N° 032.
- b) Chemicals (and Compatibility). The materials used in Flexible Plug Expansion Joints are not required to demonstrate resistance to solvents and fuels. However, the performance of materials used in this type of joint are generally required to show performance no lesser than that of the bituminous surfacing. Materials shall be compatible and shall not deteriorate as a result of chemical action.
- c) Loss of performance due to ageing resulting from temperature, UV radiation and ozone. Flexible Plug Expansion Joints shall be resistant to weathering effects including ozone, UV radiation and solar radiation. The surface of joints shall show no deterioration of performance characteristics over the intended working life as a result of exposure to the effects described above.

For other aspects: not relevant for this product family.

4.1.7.2 Aspects of serviceability

See Part 1 of this ETAG N° 032.

Accessibility for inspection is not considered relevant to Flexible Plug Expansion Joint.

4.1.7.3 Aspects of identification

See Part 1 of this ETAG N° 032.

A Flexible Plug Expansion Joint is supplied to construction site as a kit of component.

The manufacturer shall identify the component by:

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

4.2 COMPONENT

See Part 1 of this ETAG N° 032.

The manufacturer shall present a list of component with the material characteristics (including tolerances) as given in Table 5.2.

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

5. METHODS OF VERIFICATION

See Part 1 of this ETAG N° 032.

5.0 GENERAL

Comprehensive table

See the comprehensive table of Part 1 of this ETAG N° 032 but the clauses in the last column 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 tests are based on experience and formulated from a performance based point of view.

The tests described in Chapter 5 shall be carried out at temperatures indicated in Annex 3M.

5.1.1.2 Mechanical resistance

Mechanical resistance of the Flexible Plug Expansion Joint shall be demonstrated by testing.

Where the mechanical resistance of materials used for bridging plates can be derived from standards, it can be verified in an appropriate way by means of calculation. For other materials for which this approach cannot be applied, complementary tests using the principles and conditions given in this family Part shall be used. The Approval Body shall agree with the manufacturer appropriate methods for testing of mechanical resistance of those bridge plate materials.

5.1.1.2.1 Calculations of bridging plate

The verification of bearing capacity at ULS of the bridging plate shall be carried out using the design situation as defined in Chapter 4 of this Part 3 and in accordance with design standards for the material uses for this bridging plate. For steel: EN 1993, for aluminium alloy: EN 1999. In case of other material and where no appropriate EN or ISO standard is available, the use of a national standard is permitted.

5.1.1.2.2 Testing of Flexible Plug Expansion Joint

The verification of mechanical resistance of the Flexible Plug Expansion Joint at SLS shall be carried out with test methods as defined in Annex 3-M of this family Part according to the design situation stated in Chapter 4 of this Part.

The test specimen dimensions and the boundary conditions shall be selected in such a way that the structural behaviour complies with the behaviour in a real structure under the most adverse conditions.

The test specimen shall contain all of the component parts as would be installed on a bridge.

5.1.1.3 Resistance to fatigue

Fatigue resistance shall be demonstrated by testing.

5.1.1.3.1 Calculations

Not applicable for this product family.

Note: For a particular component, such as bridging plate for example, it could be appropriate to carry out fatigue verification by calculation.

5.1.1.3.2 Testing

The test specimen dimensions and the boundary conditions shall be selected in such a way that the structural behaviour complies with the behaviour in a real structure under reduced conditions of opening of the joint gap. The test specimen shall be subjected to repeated dynamic loading as stated in Chapter 4 using the over-rolling test as described in Annex 3-M of this family Part.

Fatigue verification due to movement is described in Annex 3-N.

The amplitude and the frequency used for the test defined in Annex 3-N shall be stated in the ETA.

5.1.1.4 Seismic behaviour

Not relevant: see 4.1.1.4.

5.1.1.5 Movement capacity

See Part 1 of this ETAG N° 032.

The nominal movement capacity for slowly occurring movements as well as fast dynamic repeated movements declared by the manufacturer shall be tested.

The respective movement capacities of slow expansion and contraction, and fast (traffic induced) expansion shall be verified by testing.

The displacement velocity (rate of application of strain) and the ambient temperature of the expansion joint can influence the performance of the joint. The test shall either link the temperature of the sample to the movement position or the test shall be carried out at the lowest temperature.

Verification of movements as a result of traffic action shall be carried out in horizontal displacement only.

In the case of a Flexible Plug Expansion Joint which incorporate provision for drainage within the joint trench, the movement capability of the system shall be assessed with the drainage system included.

The test methods are described in Annex 3-N of this Part of the ETAG N° 032.

Note: It is assumed that the filling material has the same behaviour to traffic action on three axes. Therefore, it is only necessary to test in the horizontal displacement.

5.1.1.6 Cleanability

Not relevant for this family Part.

5.1.1.7 Resistance to wear

See Part 1 of this ETAG N° 032.

If the kit contains component(s) subject to wear according to Part 1, verification is covered by the assessment of movement capacity (see test method in Annex 3N).

5.1.1.8 Watertightness

See Part 1 of this ETAG.

For the verification of watertightness of the joint, the test method is described in Part 1, Annex L. The test is executed during test methods described in Annex 3-N at the maximum opening position.

5.1.2 Safety in case of fire

According to Part 1: 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

Not relevant for this family Part.

5.1.4.1.2 Level differences in the running surface

Without loading, see Part 1 of this ETAG N° 032.

After loading, verification shall be carried out by test of the assembled kit as stated in Annex 3-M, 3-M7, point bis.

5.1.4.2 Skid resistance

See Part 1 of this ETAG N° 032.

5.1.4.3 Drainage capacity

Not relevant for this family Part.

5.1.5 Protection against noise

According to Part 1: Not relevant.

5.1.6 Energy economy and heat retention

According to Part 1: Not relevant.

5.1.7 Aspects of durability, serviceability and identification of the products

As far as necessary for the satisfaction of the CPD not covered by 5.1.1 to 5.1.6 (Cf. ETA-format, paragraph II.2).

5.1.7.1 Aspects of durability

See Part 1 of this ETAG N° 032.

Provided that the system is composed of conventional materials normally used for the construction of flexible plug joints then the verification of durability to the factors stated in Part 1 shall be done based on common knowledge and/or experience of the component materials already in use. The exception is the effect of temperature, which is covered in the testing of component (5.2).

The aspects related to the durability of a Flexible Plug Expansion Joint constructed with binder other than bituminous mixture materials that shall be taken into account are:

5.1.7.1.1 Corrosion

See Part 1 of this ETAG N° 032.

5.1.7.1.2 Chemicals (and Compatibility).

See Part 1 of this ETAG N° 032.

5.1.7.1.3 Ageing resulting from UV radiation, temperature and ozone

See Part 1 of this ETAG N° 032.

5.1.7.2 Aspects of serviceability

See Part 1 of this ETAG N° 032.

The Technical Manual shall be examined to determine the serviceability of the product.

5.1.7.3 Aspects of identification of the product

See Part 1 of this ETAG N° 032.

A Flexible Plug Expansion Joint is supplied to the construction site as a kit of component.

5.2 COMPONENT

See Part 1 of this ETAG N° 032.

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

Table 5.2 below gives 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.

Table 5.2: List of component

Material/Component	Characteristics		Test method(s)
Binder and precoat layer (if necessary)	Density		ISO 3838
	Segregation		Annex 3-P
	Softening point		EN 1427
	Elastic recovery		EN 13880-3 or EN 13398
	Ductility at 0 °C (incl. force-deformation-graph)		EN 13589
	Resistance to heating (8 hours at manufacturers heating temperature)		EN 12607-3
	Dynamic viscosity/temperature characteristics		Annex 3-P
	Determination of complex modulus G* vs temperature		
	Flow length at 60 °C		EN 13880-5
	Composition test (Cf. 3-P.1.10) Soluble/insoluble binder & filler content		Annex 3-P
	Composition test (Cf. 3-P.1.11) Gel Permeation Chromatography		
	Primer		EN 14188-4
	Aggregate and surface dressing	Type (petrographical description) and grain size	
Particle size distribution		EN 933-1 and -2	
Specific density, water absorption		EN 1097-6	
Bulk density		EN 1097-3	
Particle shape		EN 933-3 or -4	
Resistance to impact stress		EN 1097-2	
Resistance to heating		EN 1367-5	
Cleanliness		EN 933 and Annex 3-P.2.2	
Joint filling mixture	Indirect Tensile Test (Strength unconfined) (Joint filling mixture)		EN 12697-23 + additional text Annex 3-P
	Void content		EN 12697-8
	Wheel tracking (A)		EN 12697-22 & additional text in Annex 3-P
Bridging plate	Steel	- Yield point, - Tensile strength, - Elongation at rupture, - Chemical composition (C-eq.)	EN 10025
	Stainless steel		EN 10088
	Aluminium (covers): Plate material: Grade 5xxx Extruded material: Grade 6xxx Excluded: grades given in EN 1999-1-3, cl. 3	- Chemical composition, - Tensile strength, - Yield point, - Stress-strain, - Elongation at rupture, - Ductility, - Charpy-V value	EN 1999 Extruded aluminium: EN 755-2
Bolts, screws, nuts, washer, profiles	Metals	Energy absorption	Charpy test
Bonding agents/sealants, sockets	Chemicals/metal	Resistance to low temperatures (Chemicals) Tensile strength resistance (metal)	

The material characteristics and performance according to Table 5.2 shall be stated in the ETA.

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 and/or Footpath and/or options: - accidental load on footway - Collision on kerb	Pass/fail Refer to 'carriageway' use category Not relevant Not relevant	No No
	Resistance to fatigue	6.1.1.3	Pass/fail		No
	Seismic behaviour	6.1.1.4	Not relevant		
	Movement capacity	6.1.1.5	Declared value		No
	Cleanability	6.1.1.6	Not relevant		
	Resistance to wear	6.1.1.7	Not relevant		
	Watertightness	6.1.1.8	Pass/fail		No
2	Safety in case of fire	6.1.2	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	Not relevant		
	Level differences in the running surface	6.1.4.1.2	Level differences and steps	Pass/fail	No
			After loading	Pass/fail	No
	Skid resistance	6.1.4.2	On carriageway and footpath	Assessment by examination of drawings criterion: pass/fail If required, assessment by testing criterion: Declared value	Yes
	Drainage capacity	6.1.4.3	Not relevant		
5	Protection against noise	6.1.5	Not relevant		
6	Energy economy and heat retention	6.1.6	Not relevant		
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, freeze-thaw, ozone	6.1.7	Corrosion	Pass/fail	No
			Chemicals	Pass/fail	No
			Ageing resulting from: - Temperature, - UV radiation, - Ozone	Pass/fail	No
			Resistance against from 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.

ULS condition: At ULS the bridge plate shall be judged as fit for purpose if it satisfies the design criteria as defined in Chapter 4 of this Part.

SLS condition: The Flexible Plug Joint up to SLS conditions shall be judged as fit for purpose provided that when subjected to the verification method in Chapter 5, there is no cracking or debonding of the filling mixture (minor cracking < 1 mm width and < 5 mm depth allowed) and the resulting deformation is less than 10 mm.

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 procedure as described in 5.1.1.3.

The product will be judged as fit for purpose provided that when subjected to the verification method in Chapter 5, there is no cracking or debonding of the filling mixture (minor cracking < 1 mm width and < 5 mm depth allowed) and the resultant deformation is less than 10 mm.

6.1.1.4 Seismic behaviour

Not applicable.

6.1.1.5 Movement capacity

The Flexible Plug Expansion Joint product will be judged as fit for purpose provided that when subjected to the verification method in Chapter 5, according to the movement capacity declared by the manufacturer, there is no cracking or debonding of the filling mixture (minor surface cracking of less than 1 mm depth and width is allowed) and the fill material remains watertight.

The results of the verification of the declared value according to the verification method given in 5.1.1.5, for the appropriate test direction, shall be stated in the ETA. The reaction forces shall be stated in the ETA.

6.1.1.6 Cleanability

Not relevant for this family Part.

6.1.1.7 Resistance to wear

Where relevant, 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, whether the assembled kit remains watertight, shall be undertaken according to the verification method given in 5.1.1.8.

If the type of connection between the expansion joint and the waterproofing of the main structure is demonstrated in the relevant clause in the ETA, the assessment shall include a pass/fail criterion.

6.1.2 Safety in case of fire

According to Part 1: 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 expansion joint, 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

Not relevant for this family Part.

6.1.4.1.2 Level differences in the running surface

The product will be judged as fit for purpose provided that it satisfies the performance requirements in 4.1.4.1.2 by means of passing the verification procedure as described in 5.1.4.1.2.

6.1.4.2 Skid resistance

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

6.1.4.3 Drainage capacity

Not relevant for this family Part.

6.1.5 Protection against noise

According to Part 1: Not relevant.

6.1.6 Energy economy and heat retention

According to Part 1: Not relevant.

6.1.7 Aspects of durability, serviceability and identification of the products

6.1.7.1 Aspects of durability

The Flexible Plug Expansion Joint system shall be judged fit for use if it can be demonstrated that the system is composed of conventional materials normally used for the construction of flexible plug joints.

The exception is the effect of temperature, which is covered in the assessment of component (6.2).

6.1.7.2 Aspects of serviceability

The Approval Body shall assess the possible effects on the performance of the product/kit due to the declared limits.

6.1.7.3 Aspects of identification of the product

The assessment shall be undertaken according to the 5.1.7.3.

6.2 COMPONENT

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

Table 6.2 below presents assessment criteria for materials according to 4.2 and 5.2 of this ETAG family Part. For component materials not covered in the table below, appropriate assessment criteria shall be used. The Approval Body shall assess the fitness for purpose of the component 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 of possible effects on the performance of the product/kit.

Table 6.2: Assessment criteria for materials and component

Material/Component	Characteristics	Specification
Binder and precoat layer (if necessary)	Density	MDV
	Segregation	MDV
	Softening point	MDV
	Elastic recovery	MDV
	Ductility at 0 °C (incl. force-deformation-graph)	MDV
	Resistance to heating (8hours at manufacturers heating temperature)	Declared value of weight loss and loss of elastic recovery and dynamic viscosity
	Dynamic viscosity/temperature characteristics	MDV
	Determination of complex modulus G* vs temperature	MDV
	Flow length at 60 °C	MDV
	Composition test (Cf. 3-P.1.10) Soluble/insoluble binder & filler content	MDV
	Composition Test (Cf. 3-P.1.11) Gel Permeation Chromatography	According to reported analysis
	Primer	EN 14188-4
Aggregate and surface dressing	Type (petrographical description) and grain size	MDV
	Particle size distribution	MDV
	Specific density, water absorption	MDV
	Bulk density	MDV
	Particle shape	MDV
	Resistance to impact stress	MDV
	Resistance to heating	MDV
Cleanliness	EN 933 and Annex 3-P.2.2	
Joint filling mixture	Indirect Tensile Test (Strength unconfined) (Joint filling mixture)	MDV
	Void content	MDV
	Wheel tracking (A)	MDV
Bridging plate	Steel Stainless steel	- Geometry - Yield point - Tensile strength - Elongation at rupture - Chemical composition (C-eq.) MDV
	Aluminium (covers): Plate material: Grade 5xxx Extruded material: Grade 6xxx Excluded: grades given in EN 1999-1-3, cl. 3	- Geometry - Chemical composition - Tensile strength - Yield point - Stress-strain - Elongation at rupture - Ductility - Charpy-V value MDV

Bolts, screws, nuts, washer, profiles	Metals	Energy absorption	MDV
Bonding agents/sealants, sockets	Chemicals/metal	Resistance to low temperatures (Chemicals) Tensile strength resistance (Metal)	MDV

MDV: Manufacturer's Declared Value with acceptable tolerance

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.

In order to allow installation of the product in the works in conformity with the ETA, the manufacturer shall provide the designer of the work the following minimum information in the meaning of Part 1:

- forces to be transmitted to the structure of the bridge which are the consequence of the presence of the joint, in particular the anchorages.

Note: These forces may be variable as the result of temperature, speed of deformation, traffic and the dimensions of the joint.

- minimum reinforcement pre-installed in the zone of anchorage of the joint in the structure,
- required dimensions in the abutment or in this part of the structure in order to allow a correct placement of the Flexible Plug Expansion Joint, in particular the depth of penetration into the parts of the structure, the dimensions of the joint and the requirements for minimum deck and abutment contact areas (for example surfacing depth, minimum distance from expansion gap to the back of the joint trench) should be recorded.

Note: Member States may have a requirement for the minimum depth of the Flexible Plug Joint.

- conditions of temperature and other effects during the installation as part of the controls to ensure a good quality of works,
- conditions of levelling to the surfaces adjacent to the joint.

For the reasons presented above the road bridge expansion joint description presented to the Approval Body shall embrace road bridge expansion joint design, materials, component, equipment, installation procedures, workmanship and methods of supervision.

The ETA holder shall have the procedures and be organized and structured to ensure a constant quality of the component of the kit and of the specialized equipment, and shall have the resources to give users (consultants, general contractors and third parties) skilled advice concerning the use of the kit. The manufacturer shall provide a technical dossier for the product and installation detailing all necessary information for a successful installation.

7.2 PACKAGING, TRANSPORT AND STORAGE

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.

7.3 EXECUTION OF WORKS

See Part 1 of this ETAG N° 032.

The conditions for design and execution of the joint into the works shall be taken from the manufacturer's installation guide. The manual shall cover all important aspects related to the site work. The manual shall at least include the following information:

Proposed format for installation instructions:

The installation instructions should have the format shown in the following list where appropriate and should contain briefly and unambiguously all the information required for the installation. Information and characteristic values not demanded by basic testing should be indicated.

The execution instructions should contain a cover page with the following information:

- * Title: installation instructions for (exact designation/name of expansion joint system)
- * Issue date of the installation instructions

Contents

- 1 Information
 - 1.1 System description
 - 1.3 Scope of application
 - restrictions of use (e.g. maximum gradient, weather conditions)
- 2 Component (tabular list in each case)
 - 2.1 Form in which supplied
 - material chemical type
 - colour
 - package size
 - storage requirements
 - 2.2 Labelling in accordance with the regulations on Hazardous Substances
With instructions for disposal of liquid residual waste quantities and hardened products including residual solid blasting materials (waste codes as given in Appendix C of the Wastes TA)
 - 2.3 Composition of the tanking and the joint filling mixture
 - material basis of binder material
 - quantity of binder material
 - particle size distribution of aggregate
 - type and source of aggregate
 - other material component by type and quantity
 - special characteristics (if applicable)
 - 2.4 Other component of the expansion joint kit
 - type of plate
 - thickness of plate as a function of the width of the joint gap
 - width of plate
 - type of fixing
 - type of sealant
 - miscellaneous
 - 2.5 Materials used in the surface dressing
 - material basis of binder (if used)
 - gritting material, particle distribution
 - miscellaneous
- 3 Installation
 - 3.1 General
 - measures for safety at work required under European regulations
 - 3.2 Description of operations
 - 3.2.1 Manufacture of the joint recess
 - in an existing pavement
 - in the case of a new construction or the renewal of a pavement
 - connecting to the waterproofing layer

- 3.2.2 Preparation of the support area and / or joint recess wall
 - preparation process (instructions for grit blasting materials, where appropriate)
 - cleaning, drying and preheating of the joint recess
 - cleaning of the surrounding area after surface preparation
- 3.2.3 Pre treatment of the concrete deck by sealing, repair, or waterproofing
 - description of pre-treatment
 - compatibility with preformed, sheet systems or liquid applied resin
 - description of application and mixing of component
 - processing requirements (minimum and maximum temperatures for materials and support area, maximum humidity, dew temperature, moisture content of support area)
 - minimum and maximum waiting periods before recoating as a function of the temperature of the support area (10 °C, 20 °C, 30 °C)
- 3.2.4 Sealing of the structural gap
 - caulking and sealing materials
 - procedure for sealing gap
- 3.2.5 Plate
 - description
 - laying of the plate
 - fixing of the plate
 - miscellaneous
- 3.2.6 Joint recess tanking
 - application process
 - desired layer thicknesses / applied quantities
 - temperatures of materials (T_{min}/T_{max})
 - temperatures of support area (T_{min}/T_{max})
 - waiting periods before installation of the joint recess filling
 - special points concerning concrete joint recess wall
 - miscellaneous
- 3.2.7 Filling of joint recess
 - weather conditions
 - installation process for individual courses/layers
 - composition/mixing proportions
 - mixing (type and duration)
 - pre-heating of stone chippings (type and duration)
 - temperatures of binder material (temperatures for preparation and installation)
 - holding time for binder material in agitation boiler
 - temperatures of stone chippings (temperatures for preparation and installation)
 - temperatures of support area (T_{min}/T_{max})
 - compaction
 - minimum and maximum waiting periods before installation of the following course/layer and the surface finish
 - desired layer thicknesses/applied quantities per sqm
 - manufacture of day joint
 - miscellaneous
- 3.2.8 Surface dressing
 - gritting time
 - application of surface dressing
 - quantity of surface dressing
 - compaction of surface dressing
 - waiting period before exposure to traffic
 - miscellaneous
- Appendix
 - additional information for safety/protection at work
 - diagrams
 - miscellaneous
 - a record of works should be maintained including depth of surfacing, weather conditions, gap width, condition of deck and asphalt.

It shall be stated in the ETA that the installation guide forms part of the ETA and thus shall always accompany the delivered system component. The ETA may take over the essential parts of the installation guide.

Where the kits involve the use of chemicals and other potentially hazardous materials, the installation guide shall give precise information on their safe disposal in accordance with national regulations, if applicable.

Where the kits incorporate flammable or hazardous component, the installation guide shall give precise information to allow safe use and application.

The conditions of installation shall guarantee a correct levelling of the joint with the level of adjacent bridge pavement.

It is assumed that the difference in levels across the bridge deck gap is less than 5 mm. If the levels are found outside this tolerance, corrective action shall be taken to bring the levels within tolerance or to negate the effect of the level differences to ensure that the plate(s) are stable and do not interfere with the correct function of the Flexible Plug Expansion Joint. The manufacturer shall show in his Technical Manual how the system will cope with level differences outside the required tolerance. Flexible Plug Joints shall be installed full depth of surfacing to form a strong bond with the bridge deck adjacent pavement layers and abutment or support layer. The requirements for the bridge deck and abutment or support layer are detailed in Chapter 7.

7.4 MAINTENANCE AND REPAIR

Guidelines for maintenance and repair, including inspection sequences and specific measures related to maintenance shall be part of the Manufacturer's Technical File.

Regular maintenance is not normally required to retain performance and to obtain the estimated working life of the Flexible Plug Expansion Joint product. However, it is recommended to monitor the performance of the joint at minimum yearly intervals.

The type and frequency of such maintenance shall be specified, and shall be part of the assessment of the kit.

SECTION THREE: ATTESTATION OF CONFORMITY (AC)

8. ATTESTATION AND EVALUATION OF CONFORMITY

8.1 EC DECISION

Refer to 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

The kit manufacturer shall keep available an updated list of component manufacturers. Copies of this list shall be made available to the CB¹ and may be made available to the Approval Body for information.

For important materials or component it may be necessary that the kit manufacturer has an additional surveillance of the production process of the component manufacturer by an audit.

In that case at least once a year each component furnisher shall be audited by the kit manufacturer. Each audit shall be made available to the CB. These audit reports shall typically include:

- Identification of the component manufacturer
- Date of audit of component manufacturer
- Summary of the results and records of the FPC since last audit
- Summary of the complaint records
- Evaluation of the component manufacturer concerning FPC
- Specific remarks as relevant
- Clear and unique statement whether the requirement of the ETA are met
- Name and position of signatory
- Date of signature
- Signature

The kit manufacturer shall make available all records of relevant results concerning the ETA and the audit reports concerning the component manufacturers and save them for at least five (5) years.

8.2.1.1.2 to 8.2.1.1.5: Refer to Part 1 of this ETAG N° 032.

8.2.2 TASKS OF THE APPROVED BODY

8.2.2.1 General

The CB may act with its own resources or subcontract inspection tasks and testing tasks to inspection bodies and testing laboratories that meet the requirements of the Guidance Paper "A" [3].

¹ CB : Certification Body

8.2.2.2 Initial Type Testing

Approval tests will have been conducted by the Approval Body or under its responsibility (which may include a proportion conducted by an indicated laboratory or by the manufacturer, witnessed by the Approval Body) in accordance with Chapter 5 of this Part of ETAG N° 032. The Approval Body will have assessed the results of these tests in accordance with Chapter 6 of this Part of ETAG, as part of the ETA issuing procedure.

These tests may be used for the purposes of Initial Type Testing².

In case of changes in the production line or plant or of component(s), there may be a need for a new ITT (see also Chapter 9) for this purpose the characteristics according to Tables 5.2 and 6.2 apply.

This work shall be validated by the notified product certification Body for Certificate of Conformity purposes.

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

Assessment of the factory production control system is the responsibility of the notified product certification body.

An assessment shall be carried out of each production unit to demonstrate that the factory production control is in conformity with the ETA and any subsidiary information. This assessment shall be based on an initial inspection of the factory.

Subsequently continuous surveillance of factory production control is necessary to ensure continuing conformity with the ETA.

It is recommended that surveillance inspections be conducted ***at least one (1) time per year***.

8.2.2.4 Certification

The notified product certification body shall issue Certification of Conformity of the product.

8.3 DOCUMENTATION

See Part 1 of this ETAG N° 032.

(4) Test plan (as part of FPC)

The manufacturer and the Approval Body issuing the ETA shall agree an FPC test plan (with accepted tolerances).

An agreed FPC test plan is necessary as current standards relating to quality management systems (Guidance Paper B, EN 29002, etc), do not ensure that the product specification remains unchanged and they cannot address the technical validity of the type or frequency of checks/tests.

The validity of the type and frequency of checks/tests conducted during production and on the final product shall be considered. This will include the checks conducted during manufacture on properties that cannot be inspected at a later stage and checks on the final product.

An example of frequency of routine tests according Table 8.3 below is given.

² "according to frequency" and "sampling regime" could be based on experience or custom and practice in a given product sector or statistical methods.

*Table 8.3A: Factory Production Control
Example of tests and frequency of control for component*

Characteristics	Test method(s)
	ISO 3838
	EN 1427
	EN 13880-3 or EN 13398
Stiffness/temperature characteristics	Annex 3-P
Flex modulus G vs temperature	
	EN 13880-5
	EN 13880-2
Homogeneous mixture (examination of binder film to ensure good dispersion of the	
	Annex 3-P.1.10.2
	EN 933-1 and 2
	EN 933-3 or 4
	EN 933
	Annex 3-P.2.2

The manufacturer shall operate a Quality Management System and this shall include at least the following written procedures for control of processes:

Table 8.3B: Procedures of the Quality Management System

	Written procedures	Frequency
Incoming material	Purchasing of raw materials and component Batch identification and traceability Acceptance test or supplier's declaration of conformity Acceptance/rejection process Approved supplier list New supplier approval process Stock control	Each delivery
Finished component and in-process tests	Sales order processing Work instructions Quality control Reject/rework	Each batch/production run
Storage and dispatch	Stock control Delivery Transport Customer billing	Each order

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 3-A to 3-L for this family Part correspond to Annexes A – L in Part 1 of this ETAG N°032, if applicable.

ANNEX 3-M

MECHANICAL RESISTANCE AND RESISTANCE TO FATIGUE

3-M.1 – OBJECTIVE

This annex specifies a method to assess by testing the resistance of an expansion joint to static as well as dynamic vertical loading resulting from the action of vehicles traversing the joint. This method is intended to assess resistance to repeated vertical load of the expansion joint.

3-M.2 – SCOPE

This method applies to Flexible Plug Expansion Joints installed on road bridges. Although generally applicable to Flexible Plug Expansion Joints installed in the asphalt surfacing applied over concrete bridge decks, it can also be used for concrete surface course and bridge decks, provided that the test specimen is suitably constructed. Testing of horizontal load is not demonstrated in this annex.

3-M.3 – TERMS AND DEFINITION

Sample: See Part 1, 3.2.1.

Test Specimen. The definition given in Part 1, 3.2.1 is modified as follow: the assembly of the expansion joint representative of the product itself and submitted for testing to assess performance against the requirements.

Deformation: the change in shape and dimension of the surface of the Flexible Plug Expansion Joint in response to the applied load and tyre action.

3-M.4 – METHOD

A section of the joint assembly (the Test Specimen) shall be mounted in the test rig and subjected to simulated traffic action by the repeated passage of a loaded pneumatic tyre over the test specimen. The temperature of the specimen and the load carried by the tyre are significant factors determining performance of the product.

3-M.5 – EQUIPMENT

The equipment shall consist of a strong frame for mounting the specimen. The pneumatic tyres shall be mounted on an axle in such a way as to be able to move over the specimen perpendicular to the axis of the joint (i.e. transverse to the joint). The tyres shall be able to pass from the surface course onto the joint and over to the adjacent asphalt surface on the other side. The tyres shall be treaded. The tyres shall be loaded via the axle. This may be achieved by directly loading the axle with suitable weights or by use of hydraulic cylinder connected to the axle. The axle shall be able to move laterally under control. There shall be a facility for control and measurement of specimen temperature.

3-M.6 – SAMPLES AND PREPARATION OF SPECIMENS

The Flexible Plug Expansion Joint model shall be installed under the responsibility of the manufacturer under observation of the testing institute.

Specimen length shall be defined as the width of the joint plus the asphalt either side of the joint. The specimen length shall be at least the width of the joint plus 3 x tyre contact length.

1. Specimen width shall be defined as the distance between the end plates mounted at each end of the joint recesses, which confine the ends of the joint filling material. The specimen width shall be 300 mm or 3 x the width of the contact area of the tyre whichever is the greater.

2. The specimen shall be constructed as a 1:1 scale of the actual joint complete with gap filling and sealing devices (bridge plates, etc.). The specimen shall be mounted on a concrete base with an asphalt over-layer. A joint recess shall be formed in the asphalt cover to contain the joint filling material. The ends of the joint recess shall be closed using steel end plates thereby containing the joint filling compound.

3-M.7 – PROCEDURE

1. The specimen shall be loaded via the pneumatic tyre.
2. Lateral movement shall be applied at least as much equivalent to the groove separation.
3. Load to be applied vertically at constant force e.g. by dead load or by hydraulic pressure.
4. No skew angle on the tyre is required.
5. Contact pressure = 0,46 MPa.
6. Contact area derived from the Load Model = 0,40 m x 0,40 m. For practical purposes other contact areas for the test tyre may be used. The width of the contact area of the tyre on the test specimen shall be a minimum of 7 cm.
7. Action of loaded tyre: Uni-directional under load (reciprocating but only one way under load).
8. Speed of traverse of the tyre at (constant over the joint surface) between 0,2 m.s⁻¹ and 1,0 m.s⁻¹.
9. No delay between passes of the tyre.
10. Number of passes shall be 2 000.
11. The test shall be carried out at 60 % of the manufacturer's maximum declared opening position. For this purpose the specimen has the gap preset to the maximum opening position and the recess filled with joint filling mixture.
12. Temperature of test shall be 45 °C unless otherwise requested by the manufacturer (between 45 °C and 60 °C). Temperature shall be constant and measured at least 20 mm into the body of the joint.

3-M.8 – EXPRESSION OF RESULTS

Displacements are expressed in mm and the forces in N.

The following results shall be recorded and expressed using charts or figures:

1. Number of passes.
2. Temperature of specimen and method of temperature control.
3. Load on the tyre and variation over test period.
4. Inflation pressure of the tyre.
5. Tyre condition.
6. Condition of specimen surface.
7. Deformation profile transverse to the joint.
8. Deformation profile longitudinal to the joint.

Note: The profile measured in item 7 and 8 shall be measured over the width of the contact area + extended to 50 mm either side. This is to take into account any build up of material along the edges of the tracked area.

3-M.9 – TEST REPORT

The test report shall refer to this annex and test procedure and include:

- The origin of the expansion joint, name of manufacturer and source of the specimen tested and how sampled.
- The product model identity, batch number, description, date of manufacture, date of sampling.
- Mass and size of sample.
- Test results as required above.
- Date of tests.
- Date of report.
- Identification of test authority and credentials of the test laboratory.

ANNEX 3-N

FPEJ MOVEMENT CAPACITY TEST METHOD

(Supplementary to Annex K of Part 1 of ETAG N°32)

3-N.1 – OBJECTIVE

This annex specifies methods to assess, by testing, the ability of an expansion joint (Flexible Plug Expansion Joint) to accommodate movement resulting from changes in the relative position of the expansion gap. Differentiation shall be made between the movement capacity under slow occurring and fast occurring deformations. Slow occurring movements cover deformations of the bridge deck gap mainly resulting from seasonal and diurnal temperature changes but also shrinkage and creep. The test assesses extension and compression performance. Fast occurring movements cover dynamically repeated deformations of the bridge deck resulting from over-rolling traffic. For each movement rate a special test procedure is described. It is the objective of each test procedure to demonstrate the manufacturer's declared values for slow as well as fast occurring movements.

3-N.2 – SCOPE

This method applies to Flexible Plug Expansion Joints installed on road bridges. Although generally applicable to Flexible Plug Expansion Joint installed in the asphalt surfacing applied over concrete bridge decks, it can also be used for concrete surface course and bridge decks of materials other than concrete provided that the test specimen is suitably constructed.

3-N.3 – TERMS AND DEFINITIONS

Sample. See Part 1, 3.2.1.

Test Specimen. The definition given in Part 1, 3.2.1 is modified as follow: the assembly of the expansion joint representative of the product itself and submitted for testing to assess performance against the requirements.

3-N.4 – PRINCIPLE

A section of the joint assembly (the Test Specimen) is mounted in the test rig and subjected to simulated bridge movements in the horizontal plane by changing the relative position of one side of the joint to the other. The movements may be relatively slow to simulate thermal changes in the bridge structure ((0,2 mm/h for test method (a)) or relatively fast (0,6 mm/s test method (b)) to simulate changes due to the effect of vehicles passing over the structure. Deformation rates higher than 0,2 mm/h for test method (a) respectively 0,6 mm/s for test method (b) may also be carried out. In this case additional tests at lower rates are not required. Because of the thermoplastic behaviour of this type of joint the temperature of the specimen at the time of application of movement is a significant factor determining performance of this type of product. The temperature of the specimen throughout the test shall correspond to the manufacturer's declared operating temperature range. The test apparatus is deformation controlled.

3-N.5 – EQUIPMENT

The equipment shall consist of a strong frame for mounting the specimen. The frame shall be arranged in two halves such that the two sides of the expansion joint can be moved with minimal friction relative to one another in a horizontal plane and vertical plane (if appropriate). The equipment shall be housed in chamber which can be climate controlled. There shall be a facility for control and measurement of specimen temperature, deformation and loads. The movements shall be applied at constant temperature or shall be programmed with temperature change. For Method a) the maximum gap opening should be connected with the minimum predicted ambient temperature and the minimum gap position with the maximum ambient temperature. For Method b) a constant temperature (minimum operating temperature) is to be preferred. The deformations have to be generated stepless and shall be continuously measured. A sinusoidal wave form shall be used. Additionally the forces should be measured. The movement function shall be generated by a controller able to create sinusoidal and other load functions and controlled directly at the specimen's gap.

3-N.6 – SAMPLES AND PREPARATION OF SPECIMENS

3.N.6.1 Specimen length shall be defined as the width of the joint plus a reproduction of the adjacent pavement, if appropriate, to ensure similar bond conditions (protection and surface course [asphalt concrete or other]) either side of the joint. The width of the joint shall be declared by the manufacturer.

Specimen width shall be defined as the distance between the end plates mounted at each end of the joint recesses, which confine the ends of the joint filling material. The specimen width shall be at least 0,2 m.

3.N.6.2 The specimen shall be constructed as a 1:1 scale (height and width) of the actual joint complete with gap filling and sealing devices, bridge plates, etc. The specimen shall be mounted on a concrete base that replicates actual bridge deck concrete preparation. A joint recess shall be formed in the surface course to contain the joint filling material. Alternatively the joint filling material may be contained in the test mould frame in the absence of a surface course. During the test the ends of the joint recess shall be open to permit movement.

3.N.6.3 The Flexible Plug Expansion Joint model shall be installed under the responsibility of the manufacturer under observation of the testing institute.

3-N.7 – PROCEDURES

Method a) Movement capacity under slow occurring movements

The specimen shall be subjected to horizontal movement to the maximum declared extension and to the maximum declared compression either:

- at a controlled temperature variation which covers the operating temperature range (initially temperature 15 °C),
- or
- at two constant temperatures, which are the lowest operating temperature for the extension and the highest operating temperature for the compression.

Temperature shall be measured at least 20 mm into the body of the joint.

The speed range for application of horizontal movement shall be a minimum of 0,2 mm per hour (any higher rate will automatically cover the normal rate).

The specimen shall be loaded at least one complete cycle (full extension, full compression and re-expansion to the original expansion gap setting).

Assessment of performance shall include:

- Assessment criteria: adhesion between asphalt and its adjacent flanks and cohesion in the joint filling mixture (no debonding),
- Integrity of the surface of the joint (no cracks or fissures),
- Watertightness at full extension,
- The tensile and compression load necessary to create the declared maximum deformations (compression; extension) shall be measured during the expansion and contraction.

Method b) Movement capacity under fast occurring movements

The specimen shall be horizontally deformed only by opening extension compared to its initial gap opening with fast occurring dynamic repeated deformations at constant temperature declared by the manufacturer.

The number of load cycles at 15 °C is 5×10^6 . The number of load cycles can be reduced to $1,3 \times 10^6$ if the test is done at the declared minimum operating temperature.

The manufacturer shall state at which temperature (15 °C or minimum operating temperature) the test is to be done.

Temperature shall be measured at least 20 mm into the body of the joint.

Assessment of performance shall include:

- Assessment criteria: adhesion between asphalt and its adjacent flanks and cohesion in the joint filling mixture (no debonding),
- Integrity of the surface of the joint (no cracks or fissures),
- Watertightness at full extension,
- After demolition of the expansion joint, expose moving part(s) and check evidence of wear.

The load-deformation-graphs (Hysteresis curve) shall be measured and recorded during the test. The stiffness value F/w for every 250 000 load cycles is to be calculated.

3-N.8 – EXPRESSION OF RESULTS

Displacements are expressed in mm and the forces in N.

The following results shall be recorded and expressed using charts or figures.

Method a) Movement capacity under slow occurring movements

- Number of test cycles,
- Temperature of specimen or temperature/movement profile as appropriate,
- Load generated during the movement cycles (e.g. load/deformation graph),
- Movements of the 2 halves of the joint relative to each other (in horizontal and vertical directions),
- Condition of specimen surface (e.g. cracking, hogging, dishing),
- Adhesion between asphalt and joint,
- After application of the watertightness test, whether there is ingress of water.

Method b) Movement capacity under fast occurring movements

- Number of test cycles,
- Movement capacity,
- Mean deformation rate,
- Temperature of specimen or temperature/movement profile as appropriate,
- Max. load generated during the movement cycles (e.g. the report shall include a load/deformation graph (Hysteresis curve) over the complete test duration),
- Stiffness values for each 250 000 load cycle,
- Loss of stiffness of the joint over the test period,
- Condition of specimen surface (e.g. cracking, hogging, dishing),
- Adhesion between asphalt and joint,
- After application of the watertightness test, whether there is ingress of water,
- the extent of damage due to wear.

3-N.9 – TEST REPORT

The test report shall refer to this annex and test procedure and include:

- The test method and test parameters used to test the product,
- The origin of the expansion joint: name of manufacturer and source of the specimen tested and how sampled,
- The product model identity, batch number, description, date of manufacture, date of sampling,
- Mass and size of sample,
- Test results as required above,
- Date of tests,
- Date of report,
- Identification of test authority and credentials of the test laboratory.

ANNEX 3-P

COMPONENT TEST METHODS

3-P.1 – BINDER MATERIAL

3-P.1.1 Segregating tendency

The procedure described is designed to determine the segregation tendency of filled bituminous materials³ to describe the stability of the masses under pouring temperature conditions. The measure of the segregation tendency is defined as the difference in ash contents of the top quarter and bottom quarter of the test specimen processed.

3-P1.1.1 Apparatus and test devices

- Cylindrical upright tubes*) of aluminium of 40 mm diameter and approximately 110 mm height, bright finish inside and outside,
- Hot cabinet for temperatures up to 250 °C at least,
- Thermometer,
- Sand bath as receptacle for 2 upright tubes,
- Incineration crucible of approximately 25 ml capacity, of porcelain or platinum,
- Muffle furnace, controllable to (900 ± 25) °C, provided with an aperture on the front plate and with a flue pipe at the back, enabling an interchange of air to take place inside the furnace,
- Desiccator with desiccant,
- Balance with an error limit of ± 1 mg.

3-P1.1.2 Samples

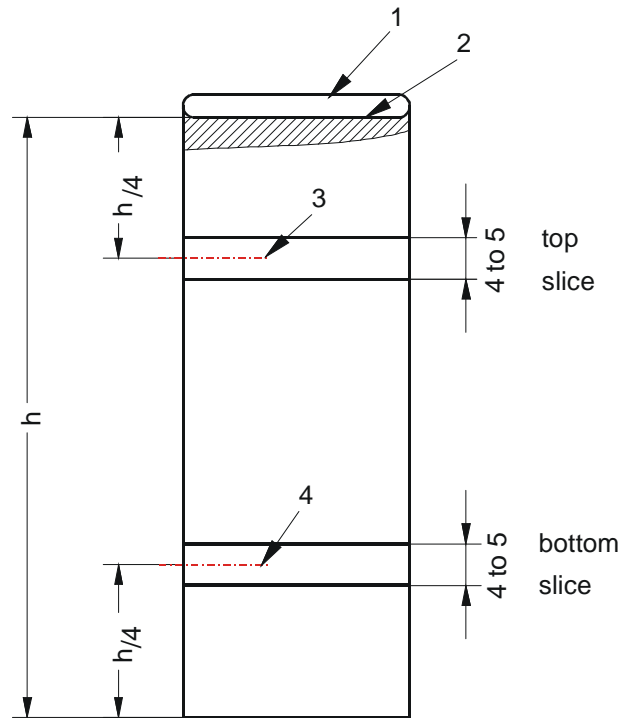
A laboratory sample shall be taken and shall be prepared. The test shall be carried out on two test specimens. After having attained the temperature specified in 3-P.1.1.3 "Procedure", the necessary quantity of sample is filled into the upright tube from the prepared sample. The quantity of sample shall be sufficient to ensure that the height of the fill in the upright tube in hot condition amounts to $100 \text{ mm} \pm 5 \text{ mm}$.

3-P.1.1.3 Procedure

The upright tube containing the test specimen is maintained at a constant temperature to within ± 2 °C in the pre-heated sand bath in the hot cabinet, immediately after the tube has been filled, for a period of 60 minutes. This test temperature shall be the pouring temperature specified by the manufacturer.

The thermometer provided for checking the temperature shall be planted in the sand bath in such a way that the temperature sensor is located mid-way between the two upright tubes in the sand bath. Thereafter the upright tube with the test specimen is cooled down by exposure to the air, then it is cooled down further on carbon dioxide or ice, and the upright tube is removed. A slice of 4 to 5 mm thickness is then cut with a heated knife blade from the zone of the top quarter point and of the bottom quarter point of the test specimen (see Figure 3-P.1). A sample quantity of approximately 5 g required for the ash determination is then cut from each of the two slices.

³ A compound of bitumen and mineral filler used as a binder in a flexible plug expansion joint. The bitumen may be modified with additives.



- 1 = Surface of the test specimen in the hot state,
- 2 = Surface of the test specimen in the cooled-down state (sectioned),
- 3 = Top quarter Point,
- 4 = Bottom quarter Point,
- h = Distance from bottom face of the test specimen to centre of top face of the test specimen in the cooled-down state after removal of the upright tube.

Figure 3-P.1: Test specimen after removal of the upright encasing tube

The ash content of the two test specimens obtained in this way is determined as follows:

- Constant mass for the ash determination is deemed to have been attained when the change in mass after renewed baking and cooling-down to room temperature in the desiccator does not exceed 6 mg.
- The crucible is baked at $(550 \pm 25) ^\circ\text{C}$ until constant mass has attained, and is weighed to the nearest 2 mg after cooling-down.

Note: A baking period of 30 minutes is usually necessary and sufficient for the baking of the empty crucible.

- Approximately 5 g of the sample are then filled into the crucible prepared as described above. The initial mass shall be measured and recorded to within 2 mg accuracy. Then the crucible is gently heated with the gas burner until the escaping vapours from the crucible burn away gently, until only ash and carbon remain. If the sample contains a large amount of moisture which is liable to froth on heating, then it will suffice to add a small amount of isopropyl alcohol or some paper. After completion of burning off, the crucible is placed in the muffle furnace and is annealed at $(550 \pm 25) ^\circ\text{C}$ until constant mass has been attained. Thereafter the crucible with annealing residue is left to cool down in the desiccator and is then weighed to within 2 mg accuracy.

Note: An annealing time of 60 minutes is usually required for annealing of the sample.

As soon as the filter paper starts burning, this is an indication that most of the water has been driven off.

3-P.1.1.4 Evaluation and presentation of result

The segregation tendency E_{abs} is calculated in % by wt. in accordance with equation (1) and is reported rounded to the nearest 0,1 % by mass:

$$E_{abs} = a - b \quad (1)$$

Where:

E_{abs}	Segregation tendency in % by mass.
a	Ash content of test specimen from the bottom quarter point, in % by mass.
b	Ash content of test specimen from the top quarter point, in % by mass.

3-P.1.1.2 Density

Density of the binder material shall be investigated. The relevant standard shall be chosen relating to the binder composition (for example ISO 3838, EN 13880, EN 15326).

3-P.1.1.3 Softening point Ring and Ball

This property shall be investigated according EN 1427.

3-P.1.1.4 Elastic recovery

This property shall be investigated according EN 13880-3.

Or alternatively

This feature shall be investigated according EN 13398 (the test shall be carried out at 0 °C).

The manufacturer shall declare which method is used in combination with the heat ageing test to determine the change in properties of the material.

3-P.1.1.5 Ductility at 0 °C

This property shall be investigated according EN 13589.

3-P.1.1.6 Resistance to heating

According to EN 12607-1 (RTFOT test).

Or

This feature shall be investigated according to EN 12607-3.

The manufacturer shall declare which method is used in combination with the heat ageing test to determine the change in properties of the material.

Different to EN 12607, the heating temperature shall be the manufacturer's heating temperature. Besides this, the condition time under the manufacturers heating temperature shall be 8 hours. After conditioning the characterisation tests shall be applied.

3-P.1.1.7 Dynamic viscosity; viscosity-temperature-characteristics

The basis is: EN 13702, Part 1 and 2.

Dynamic viscosity shall be investigated in a rotating viscometer complying with EN 13702. The measurement equipment consists of a plate-plate measuring system with the upper plate having a diameter of 25 mm and a bedplate diameter of 55 mm. As a function of the characteristics of the binder material and the area of application of the viscometer, the application of other measurement geometries (cylindrical measurement system Z4) and/or differing diameter may prove necessary.

Measurements shall be performed at temperatures of 60 °C, 100 °C and 140 °C, and at the heating temperature stated by the manufacturer, on fresh samples of the binder material in each case. After the relevant temperature is set with a precision of 0,1 K, in the plate-plate measurement mode the zero point of the movable top and then the selected plate gap are set without sample material. For the tests described here, a gap of 1 mm is set as a rule but this shall be checked and re-specified for each binder material as required, as a function of the mean particle size of the filler of the binder material and the measurement range of the viscometer. The criterion here is that the plate gap shall be 5 to 10 times larger than the largest particle diameter in the binder material in order to prevent turbulent flow phenomena. This is also valid for cylindrical measurement mode.

In order to guarantee comparability in the results, the same shearing-strain gradient and determination of viscosity at identical shearing strain are necessary. As a function of the measurement geometry, a certain volume of binder material shall be placed and then be melted carefully by means of temperature equalization to the temperature of the softening point by ring and ball method or the softening point by the Wilhelmi method. Overfilling or under filling of the test gap with the test material shall be excluded; the measurement temperature shall be approached. After temperature equilibrium is reached, a temperature adaptation of 20 minutes shall be effected and the measurement shall then be made.

In order to record the flow curves, the shear velocity shall be continuously increased as a function of the applied shear force in the so-called "shear-force-controlled measurement mode" in the range 0 – 2 000 Pa with a constant shearing-strain gradient of 12,5 Pa/s in the various temperature ranges. A recording density of one measured value every seven seconds shall be selected. Dynamic viscosity in [Pa s] shall be determined from the following equation:

$$\eta = \tau / D \text{ [Pa/s]}$$

where

- τ = shear force in Pa
- D = shear gradient in s⁻¹
- η = dynamic viscosity in Pa/s

The dynamic viscosity of the binder material at the test temperatures mentioned above shall be determined at a shear force of 100, 250, 500 and 1 000 Pa. The viscosity-temperature curve shall be drawn.

3-P.1.8 Determination of complex modulus G* versus temperature

The test method of EN 14770 shall be used with the following precisions.

The determination of the dynamic-mechanical behaviour over a temperature range from -30 °C up to +140 °C (temperature sweep) and the interpretation of the results is according ISO 6721. Temperature sweeps at constant frequency and constant amplitude or constant shear force shall be used for the measurement of the dynamic-mechanical behaviour of the binder mass. The shear force required for deformation and the deformation amplitude shall be measured. Depending on the binder material (for instance the dimension of the filling materials) and the test equipment, a plate-plate measuring device (e.g. diameter of 12,5 mm, 25 mm or 50 mm) or cylindrical measuring device shall be used as the measuring geometry. The gap between the plates to fill in the test material shall have a minimum distance of 2 – 3 times the dimension of the filler materials. The preparation of the test and the installation of the sample shall comply with the procedure given in the section before. The measurement frequency shall be 1 Hz. The tests shall be performed with falling temperature.

First, in a preliminary test, the deformation range within which the structure of the investigated binder material is retained (linear viscoelastic range), shall be determined by a so-called "amplitude sweep". While observing the limits thus set for deformation, the complex modulus, storage modulus, loss modulus and loss angle shall then be determined (for most products, a deformation amplitude of 0,005 has been shown to be expedient). The dynamic elastic characteristic values shall be calculated from the following equations:

$G' = [\sigma_0 / \epsilon_0] \times \cos \delta$	storage modulus G'
$G'' = [\sigma_0 / \epsilon_0] \times \sin \delta$	loss modulus G''
$G^* = [(G')^2 + (G'')^2]^{1/2}$	complex modulus
$\tan \delta = G''/G'$	loss factor

where:

- σ_0 = shear-force amplitude in Pa,
- ϵ_0 = deformation amplitude,
- f = angular frequency in s^{-1} ,
- $|G^*|$ = complex modulus in Pa,
- G' = storage modulus in Pa,
- G'' = loss modulus in Pa,
- δ = loss angle.

The dynamic elastic characteristic values shall be recorded over a temperature range of -30 °C to 140 °C and serve as a rheological fingerprint for the relevant binder material.

3-P.1.9 Flow length at 60 °C

This feature shall be investigated according EN 13880-5.

3-P.1.10 Composition of the binder material

The composition of a bituminous mass shall be determined by extraction with solvents, mechanical separation of the insoluble component from the soluble component and incineration of the insoluble organic contents. In the extraction the nature of the binder, fillers and additives shall be considered. Furthermore, certain conditions relating to extraction speed, etc. may be complied with. If the manufacturer of the binder material has not specified any solvent for the extraction, toluene shall be used. In addition to the filler sieve, a wire sieve tray with a mesh of 0,2 mm complying with ISO 3310-1, shall be used as a protective sieve.

After extraction, the fillers are separated by sieving and then centrifugation. They may be inorganic fillers (rock dust) and/or insoluble organic fillers (rubber powder).

3-P.1.10.1 Proportion of soluble binders in the binder material

The investigation shall be performed in accordance with EN 12697-1 using the Soxhlet-procedure. The residues separated out in centrifugation and any that are left on the sieves shall be rinsed with solvents until the liquid draining off remains practically colourless. The residues shall then be dried for 15 hours in air under a laboratory extractor and then at $(110 \pm 5 \text{ °C})$ to constant mass. After cooling in a desiccator (drying agent: silica gel), the fillers remaining on the sieves and in the beaker of the through flow centrifuge shall be gravimetrically determined and stated, with consideration of the initial mass of the sieve and/or beaker of the through flow centrifuge (tare). The sum of the individual amounts shall be stated as mass of insoluble component $m_{A,Unl}$. The proportion of soluble binders in the binder material is then given by the following equation:

$$B_{\text{ösl}} = (m_{E,0} - m_{A,Unl}) / m_{E,0} \times 100 \text{ [M.-\%]}$$

where

- $m_{A,Unl}$ = mass of recovered insoluble component in the binder material [g],
- $m_{E,0}$ = originally weighed-in quantity of sample [g],
- $B_{\text{ösl}}$ = proportion of soluble binders in the binder material [% by mass].

3-P.1.10.2 Proportion of inorganic fillers in the binder material

A new sample of the binder material shall be prepared and shall be incinerated in accordance with EN 12697-39 at an incandescent temperature of $T = 550 \text{ °C}$. To calculate the proportion of inorganic fillers, the gravimetrically determined ash residue $m_{A,M}$ after incineration is referred to. The content in terms of inorganic fillers in the binder material is given as % by mass by the following equation:

$$M = (m_{A,M} / m_{E,0}) \times 100 \text{ [M.-\%]}$$

Where:

$m_{A,M}$ = mass of ash residue [g],
 $m_{E,0}$ = originally weighed in quantity of sample for determination of binder content [g],
 M = content in terms of inorganic fillers (e.g. mineral aggregate) in the binder material [% by mass].

3-P.1.10.3 Proportion of insoluble organic component

This investigation shall be based on the results of the procedures described in the sections above. First the mass of the insoluble content $m_{A,Unl}$ obtained after extraction and the ash residue $m_{A,M}$ after incineration at $T = 550 \text{ }^\circ\text{C}$ are determined. The proportion of total insoluble organic component (insoluble binders and insoluble organic fillers) is given by the following equation:

$$G_{ges} = 100 - B_{lösl} - M \text{ (M-\%)}$$

where

G_{ges} = proportion of insoluble organic component in the binder material [% by mass],
 M = content in terms of inorganic fillers (e.g. mineral aggregate) in the binder material [% by mass],
 $B_{lösl}$ = proportion of soluble binders in the binder material [% by mass].

3-P.1.11 Composition of the binder molecular fingerprint

For the binder material the Gel Permeation Chromatography (GPC) method may be used.

This method is useful for the identification of the binder (fingerprint) and determination of the thermal damage of the binder during application.

The GPC-fingerprint of the binder has to be determined during ITT.

Comparing the fingerprint of a sample with the fingerprint of ITT, it can be verified whether the correct binder in the approved system is used or whether the binder has been modified in terms of polymer content, polymer type and binder origin. It may be used as quality control to identify changes in manufacturing or it may show that problems have arisen during construction.

Method

The molecular mass distribution relative to polystyrene and the *relative* amount of the polymer in the binder are determined using gel permeation chromatography (GPC). GPC separates the compounds in solution according to their size in solution. The approximate molecular mass is deduced from the analysis of a polystyrene standard under the same conditions.

GPC equipment:

Detectors:

- UV-detector with single wavelength detection between 200 and 300 nm,
- Universal detector such as refractive index detector (RI detector), Evaporative Light Scattering Detector (ELS detector), etc.

Note: Results between different detectors are not comparable.

- Column oven: Temperature range $20 \text{ }^\circ\text{C} - 40 \text{ }^\circ\text{C}$, temperature constancy: $\pm 0,1 \text{ }^\circ\text{C}$.

GPC-Column: Range of molecular mass distribution: 200 to 1 000 000 g/mol
 Column efficiency: >20 000 plates

Solvent Tetrahydrofuran (THF) HPLC-grade. For UV-Detection at 215 nm non-stabilised high purity Tetrahydrofuran with low absorbance at 215 nm is necessary.

Syringe filter Disk filter with 0,2 - 0,5 μm pore size, compatible with the solvent used.

Polymer standard: Polystyrene

Test parameters:

- Number of injections: minimum 2 for each sample;
- Sample concentration: depending on the injection volume and detector type: For RI detectors concentrations of 10 to 50 mg binder per ml and for UV-Detector about 1 to 5 mg binder per ml Tetrahydrofuran (THF) are typically for 50 µl injection volume;
- Flow rate: 1 ml/min;
- Sample rate of the detector: 1 per second;
- Injection volume: 10 - 50 µl (depending on detector type and sample concentration);
- Oven temperature: 30 ± 0,1 °C;
- Wavelength of UV-detector: 215 nm;
- Sampling.

Binder samples are taken with a cold knife. If homogeneity of the binder is a problem, at least two samples have to be taken at different places. A minimum amount of 200 mg binder per sample has to be taken. The binder is dissolved in THF and diluted to the desired concentration. Check whether the binder has properly dissolved before the first dilution step. The solutions are filtered through the disc filter to prevent clogging of the GPC-column with filler and rubber particles.

GPC-Analysis

Before starting the analysis, ensure the base line and the retention time are constant. The first and last sample shall be a standard, to be sure that the conditions of the analysis have not changed.

To identify component coming from the solvent, filter, syringe, etc., a blank sample (THF) has to be analysed with the same procedure. It is important that the blank sample undergoes the same pre-treatment (filtration, dilution, etc.) as the binder samples.

Calibration:

To determine the molecular size distribution a calibration curve shall be made with a minimum of four polystyrene standards with peak molecular mass in the range of 200 up to 1 x 10⁶ Daltons. Depending on the column type a linear or polynomial calibration curve has to be applied.

Data analysis:

The determination of the molecular mass distribution of the polymers and bitumen is made using the calibration curve with polystyrene standards. The molecular mass M_w is a function of the retention time R_t : $\log(M_w) = f(R_t)$

Area-% F_i determined from the Chromatogram is referred to the area of the bitumen and polymer peaks and not to the mass of the binder and shall be calculated as follows:

$$F_i = P_i / P_s \cdot 100\%$$

- F_i : Area-% of the determined peak,
 P_i : Area of the peak in the chromatogram,
 P_s : Total area of all polymer and bitumen peaks (without artefacts).

Report

The following information has to be included in the report:

- Sample parameters: type and complete identification of the sample, sample concentration,
- Detector parameters: detector type, sample rate, wavelength, etc.,
- Solvent used with solvent purity,
- GPC-parameters: temperature of the analysis, injection volume,
- Date of sample preparation and analysis,
- Result of the GPC-analysis: peak molecular mass and area-% of each polymer and bitumen peak for all detectors,
- GPC-chromatogram,
- All deviation from this annex,
- Reference to this annex.

Proposal for allowable tolerances:

Peak Molecular Mass

Permissible range:	
Repeatability conditions (one observer; one apparatus):	10 %
Reproducibility conditions (different observers, different apparatus):	x
Allowable tolerance (against results of ITT) for certification of conformity:	x

Relative Peak area:

Permissible range:	x
Repeatability conditions (one observer; one apparatus):	x
Reproducibility conditions (different observers, different apparatus):	x
Allowable tolerance (against results of ITT) for certification of conformity:	x

3-P.1.12 Dispersion of polymer in bitumen

The test method of EN 13589 shall be used with the following precisions.

This test is a visual, qualitative test to check the dispersion of polymer in bitumen during the production process.

A liquid sample of bitumen polymer mixture is taken from the mixer/disperser equipment prior to addition of fillers.

The hot mixture is poured and spread in an approximate disc shape 10 cm diameter and 5 mm thick. While the mixture is still warm, the disc is stretched to form a thin translucent film and viewed against a light source.

The material shall be flexible, form a continuous film and be free from undispersed particles of polymer.

3-P.2 – AGGREGATE MATERIAL

3-P.2.1 Mineral aggregate type

The mineral aggregate type of the deposit (e.g. diabase, granite) from which the stone chippings were obtained shall be determined in accordance with EN 932-3.

3-P.2.2 Particle size distribution and cleanliness of particles

Particle size distribution shall be determined in compliance with EN 933-1 and EN 933-2 using the hand-sieving method by means of dry sieving. The particle-size distribution curve of the stone chippings shall be shown as through fraction in % by mass over the root of the sieve mesh size.

Cleanliness shall be determined by the method described in EN 13043.

3-P.2.3 Density, specific density and porosity

The density, specific density and porosity of the stone chippings shall be determined in accordance with EN 1097-6.

3-P.2.4 Bulk density

In addition to density and dry specific density, bedding density when loosely heaped (bulk density) shall be included in considerations. This enables calculation of cavity content between the individual aggregate particles and thus gives an indication of the size of the volume of the binder material required to fill the cavities completely.

In order to determine the cavity content between the individual aggregate particulates when loosely heaped, the investigation of bulk density shall be executed in compliance with EN 1097-3.

3-P.2.5 Particle shape

The most compact and cubic shape possible is required of the stone particles in order to ensure the flexibility. This requirement shall be tested by recording the ratio of the length l to the thickness s of the particle in compliance with EN 933-4.

3-P.2.6 Resistance to impact stress

The impact-shattering value shall be determined in compliance with EN 1097-2.

3-P.2.7 Resistance to thermal effects

The resistance of the stone chippings to thermal effects shall be investigated in accordance with EN 1367-5.

3-P.3 – JOINT FILLING MIXTURE

3-P.3.1 Indirect tensile strength

This feature shall be investigated according EN 12697-23 but different from the technical rule at a test temperature of $-20\text{ }^{\circ}\text{C}$.

3-P.3.2 Void content

Test procedure according EN 12697-8.

3-P.3.3 Wheel tracking

Test procedure according EN 12697-22.

The rutting resistance property of the joint filling material shall be assessed by the use of the EN 12697-22.

Note: The safety margin of $15\text{ }^{\circ}\text{K}$ is given as given in 2.3.2 of Part 1 of this ETAG N° 032 for surface area exposed to sun is not applied for this test.

ANNEX 3Q

MECHANICAL RESISTANCE – CALCULATION OF LOADS

Informative annex.

3.Q.1 – GENERAL

Loads and loading conditions are determined according to Part 1 of this ETAG N° 032: Annex G and EN 1991-2.

See also Part 1 of this ETAG N° 032.

Traffic loads on road bridges derived from Eurocode 1 (EN 1991-2).

Using static load model LM1 in Part 1 of this ETAG N° 032 (Annex G.2).

Load conditions as relevant to Flexible Plug Expansion Joint and their required performance are represented by the following formulas.

Expansion joint parameters (Part 1, Figure G2 and Table G2). For Flexible Plug Expansion Joint type joints:

$$L_j(\text{fpej}) \leq 0,5 \text{ m}; \quad W_j(\text{fpej}) \leq 1,2 \text{ m}; \quad Q_{1k} = 300 \text{ kN}$$

3-Q.2 – ULS LIMIT STATE

At ULS the design situation is given by:

$$C_{ULS} = \psi_{0T} \gamma_{Q1} Q_{1k} "+" \psi_{0d} \gamma_{dE} d_{Ek} \quad [\text{EQ. M4.1}]$$

Where:

- Q_{1k} = Axle load,
- γ_{Q1} = Partial factor traffic loads,
- ψ_{0T} = Combination factor for traffic loads,
- ψ_{0d} = Combination factor for opening position,
- d_{Ek} = Maximum manufacturer declared opening position of the joint.

Table 3-Q.2a: Partial factors γ

Partial factor	Unfavourable	Favourable	Remark
γ _{Q1}	1,35	Not applicable	Partial factor for traffic loads lane 1
γ _{dE}	1,00	Not applicable	Partial factor for opening positions of the joint

Table 3Q.2b: Combination Factors (E₀)

C _{ULS}	Design situation	E _{0T}	E _{0d}
1	Reduced opening position with maximum traffic loads, flowing traffic	1,00	0,60
2	Maximum opening position with reduced traffic loads	0,70	1,00

Note: As an envelope approach, covering all design situations, the ψ₀ factors can be taken as follows: ψ_{0T} and ψ_{0d} = 1,00.

Design situation C_{ULS1}:

$$C_{ULS1} = 1,0 \times 1,35 \times 300 \text{ kN} "+" 0,60 \times 1,0 \times d_{Ek} \quad [\text{EQ. M4.2}]$$

C_{ULS1}: Q_{1d} = 405 kN with 60 % of manufacturer's declared opening (d_{Ek})

Design situation C_{ULS2} :

$$C_{ULS2} = 0,7 \times 1,35 \times 300 \text{ kN} "+" 1,0 \times 1,0 \times d_{Ek} \quad [\text{EQ. M4.3}]$$
$$C_{ULS2}: Q_{1d} = 284 \text{ kN with full manufacturer's declared opening (} d_{Ek} \text{)}$$

Calculation of contact pressure

$$\text{Design contact pressure} = \text{contact} = \gamma_{Q1} [(Q_{1k} / 2) \times (1/\text{contact area})] \quad [\text{EQ. M4.4}]$$

$$\text{contact} = 1,35 \times 150 \times 0,0067 = 1,35 \text{ N mm}^{-2}$$

This design contact pressure may be reduced at the bridging plate with the application of the dispersal effect (D) in accordance with EN 1991-2, 4.3.6.

D = Dispersal effect of bridge deck surfacing and thickness of Flexible Plug Expansion Joint (effectively the ratio of contact area at surface level (A_1) over the contact area at the level of the bridge plate (A_2)).

3-Q.3 – SLS LIMIT STATE

At SLS the design situation is given by:

$$C_{SLS} = \psi_{0T} Q_{1k} "+" \psi_{0d} d_{Ek} \quad [\text{EQ. M4.5}]$$

Where:

Q_{1k} = Axle load,

ψ_{0T} = Combination factor for traffic loads,

ψ_{0d} = Combination factor for opening position,

d_{Ek} = Maximum manufacturer declared opening position of the joint.

As an envelope approach, covering all design situations, the ψ_0 factors can be taken as follows:

$$\psi_{0T} \text{ and } \psi_{0d} = 1,00.$$

Design situation C_{SLS1} :

$$C_{SLS1} = 1,0 \times 300 \text{ kN} "+" 1,0 \times d_{Ek} \quad [\text{EQ. M4.6}]$$
$$C_{SLS1}: Q_{1d} = 300 \text{ kN with full manufacturer's declared opening (} d_{Ek} \text{)}$$

Calculation of contact pressure

$$\text{Contact pressure (SLS)} = \text{contact,SLS} = [(Q_{1k} / 2) \times (1/\text{contact area})] \quad [\text{EQ. M4.7}]$$

$$\text{contact} = 150 \times 0,0067 = 1,00 \text{ N mm}^{-2}$$

3-Q.4 – FATIGUE LOADS

See Part 1 of this ETAG N° 032 and Table 4.1.1 of this family Part.

Note: Resistance to fatigue in the context of Flexible Plug Expansion Joint is not the fatigue in the classic sense of, for example, mechanical behaviour of metals used in mechanical joints. This is because the materials behave in rather different manner to metals.

Resistance to fatigue for testing Flexible Plug Expansion Joint shall be demonstrated in two ways:

- Repeated loading by vehicle wheels which typically would lead to deformation or wheel rutting, taking into account dynamic loading by traffic.
- Loading of the structure resulting in fast movements at the expansion gap which have to be accommodated by the expansion joint (see test methods in Annex 3-N of this Part).

Dynamic loads

Using fatigue load models in Annex G.3, Fatigue Load Model 1 (FLM1_{EJ}) assumes infinite fatigue life of joint. For this it is useful to have data on σ_D (Constant amplitude fatigue limit) but until such time as this is available for this family of joint it is better to use Fatigue Model FLM2_{EJ}.

Table 3Q.3: Vertical loads for fatigue (axle load distribution derived from EN 1991-2)

$Q_{1k,fat}$ (From Table G4) Vertical axle load kN	$Q_{1k,fat}$ Applicable to FPEJ Vertical axle load kN	Axle number rate	Axle type
100	77	1,10	A
120	92	1,25	C
150	115	0,20	B
170	131	0,45	B
190	146	0,45	B

For axle types, wheel prints and axle geometries see Annex G Table G.3 in ETAG 032 Part 1.

The loads mentioned in Part 1 of this ETAG N° 032, Table G4, include the following additional amplification factors:

$$\Delta\varphi_{fat} = 1,3 \text{ and } \Delta\varphi_{fat,h} = 1,0.$$

For Flexible Plug Expansion Joint they do not apply and the $\Delta\varphi_{fat} = 1,0$.

Horizontal loads for Flexible Plug Expansion Joint do not apply.

Combination for fatigue limit state:

$$C_{FAT} = Q_{1k,fat} \cdot \psi_{0d} d_{Ek} \quad [EQ. 4.8]$$

Where

$\psi_{0d} = 0,6$ Combination factor

$d_{Ek} =$ Maximum declared opening position of the joint.

$C_{FAT}: Q_{1k,fat} = 146$ kN with 60 % of manufacturers declared opening position of the joint.

Contact pressure (FAT)

$$\begin{aligned} \text{contact}_{,fat} &= [(Q_{1k,fat} / 2) \times (1/\text{contact area})] & [EQ. 4.9] \\ \text{contact}_{,fat} \text{ (at surface)} &= 0,49 \text{ N mm}^{-2} \end{aligned}$$

$Q_{1k,fat}$ are axle loads in relation to the number of vehicles for the fatigue load model considered, the number of vehicles (N_{obs}) shall be in accordance with EN 1991-2 and Part 1 of this ETAG N°32.