EAD 120111-00-0107

August 2019

CANTILEVER EXPANSION JOINTS FOR ROAD BRIDGES

Adopted European Assessment Document according to
Regulation (EU) № 305/2011, Annex II 7.

European Organisation for Technical Assessment www.eota.eu

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD covers cantilever expansion joints for road bridges.

Cantilever expansion joints for road bridges are used to ensure the continuity of the running surface and its load bearing capacity and the movement of the bridges whatever the nature of the structure constitutive material is.

A cantilever expansion joint consists of cantilever symmetrical and non-symmetrical elements (such as comb, saw-tooth or sinusoidal plates – examples of finger shapes of cantilever expansion joints are given in Annex A), which are anchored on one side of the deck joint gap and interpenetrate to bridge the deck joint gap. The elements are flush with the running surface.

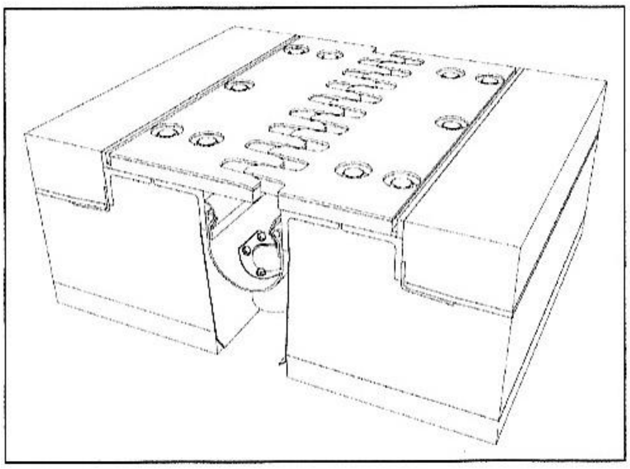


Figure 1: Example of a cantilever expansion joint (3D view)

Note: This example shows one possible design of cantilever expansion joints, other designs are possible.

Figure 2 shows typical shapes of cantilever expansion joints in plan.

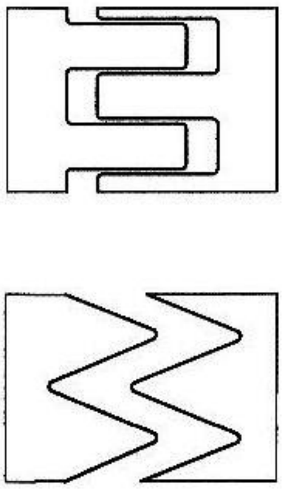


Figure 2: Examples of typical shapes of cantilever expansion joints

A cantilever expansion joint kit consists at least of the following:

- Finger plates made of metal
- Anchorage system

In addition, the following optional components may be included in the kit to be assessed and subject of the ETA:

- Kerb elements
- Covers for pedestrian areas
- Devices for running surfaces (cyclist areas)
- Support structure (linking the joint to the main structure)
- Adaptations for snow plough impacts (e.g. impact protection strip)
- Devices for watertightness (sealing element) or sub-surface drainage system (gutter)
- Connections to the watertight membrane
- Drainage device made of aluminium or stainless steel (defined in EAD 120109-00-0107, Annex D, Figure D.11)

The material used for connecting the joint to the substructure (e.g. concrete for recess filling and reinforcement in case of concrete bridges) considered in the assessment of the product shall be described in the ETA but is not forming a part of the product covered by the ETA.

Flexible devices for watertightness or sub-surface drainage systems made of elastomer are based on Polychloroprenerubber (CR), Ethylene-Propylene-Diene Material (EPDM), Styrol-Butadiene-Rubber (SBR).

Rigid sub surface drainage systems made of plastics are based on PVC or PE or made of stainless steel or galvanized steel.

Cantilever expansion joints according to this EAD are related to the atmospheric corrosivity categories C4 or C5 according to EN ISO 9223, whereas durability classes according to EN ISO 12944-1 and EN ISO 14713-1 respectively apply.

This EAD applies for products with the following corrosion protection aspects:

- Structural steel surfaces in contact with concrete have no coating. Only at the transitions an overlap of approximately 50 mm of the full corrosion protection system is applied.
- In case of use of stainless steel for components, the steel type is selected under consideration of the corrosivity categories of the atmosphere using the conditions given in EN 1993-1-4, Annex A, A.2, A.4 and A.5.
- Aluminium alloys have a corrosion resistance of at least category “B” according to EN 1999-1-1, Table D1, or equivalent. Furthermore, interaction between concrete and the aluminium alloy is prevented.
- Permanent steel bolts are at least electrolytic zinc plated. For coating with Fe/Zn 25 EN ISO 2081 applies, for hot dip galvanisation EN ISO 10684 applies. In case of stainless steel EN ISO 3506-1 applies, whereas EN 1993-1-4, Annex A, A.2, A.4 and A.5 needs to be considered.

In case of using aluminium for the finger plate, this should be accompanied by the following information to be stated in the ETA:

- Declaration about protection of aluminium parts when in contact with concrete under humid circumstances
- Information about insulation measures taken to avoid galvanic elements (electrolytic corrosion)

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

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer’s instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The product according to this EAD is intended to be used for road bridges.

1.2.1.1 Operating temperature categories

The operating temperature is defined as the shade air temperature according to EN 1991-1-5, clause 1.5.2.

The product according to this EAD is intended to be used under operating temperatures given below:

- Levels of minimum operating temperature categories: -10 °C, -20 °C, -30 °C, -40 °C
- Levels of maximum operating temperature categories: +35 °C, +45 °C

Operating temperature range shall be stated in the ETA.

1.2.1.2 Use categories

The use categories to be stated in the ETA are specified with regard to the user and action categories.

1.2.1.2.1 User categories

- Vehicle
- Cyclist
- Pedestrian

1.2.1.2.2 Actions categories

- Standard action (traffic load action)
- Optional action (accidental effects of heavy wheel on footpath, seismic phenomena; wheel shock on the upstand)

Actions are defined in EAD 120109-00-0107, Annex D, Clause D.2.3 and D.2.4.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the cantilever expansion joint for road bridges for the intended use according to the working life categories as given in the Table below when installed in the works (provided that the cantilever expansion joint for road bridges is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

The intended working life of the kit is based on the following working life categories, with N_{obs} = 0,5 million/year or (see EN 1991-2, Table 4.5 and EAD 120109-00-0107, Annex D, Clause D.2.3.3).

Working life categories of the expansion joint kit

Working life category	Years
1	10
2	15
3	25
4	50

Replaceable components which have a working life shorter than for the kit shall be indicated in the ETA.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Art 2)

For definitions, abbreviations and symbols regarding the terminology applying for assessment of mechanical resistance, resistance to fatigue and seismic behaviour EAD 120109-00-0107, Annex D applies. For additional terms and definitions specific for this EAD, see below.

1.3.1 Support structure

Intermediate structure connecting surface elements and anchorage system to the main structure.

1.3.2 Finger plates

Load bearing surface elements fixed to the bridge structure.

1.3.3 Anchorage system

Bars and/or rods that connect the cantilever expansion joint to the main structure or the abutment.

1.3.4 Sealing element

A flexible element which ensures the watertightness of the cantilever expansion joint.

1.3.5 Sub-surface drainage system (gutter)

Component with the purpose of draining surface water from the expansion joint.

1.3.6 Secondary elements

Components of the kit not contributing to mechanical resistance and stability of the kit.

1.3.7 Batch

Quantity of product or components manufactured to the same specification within a determined period.

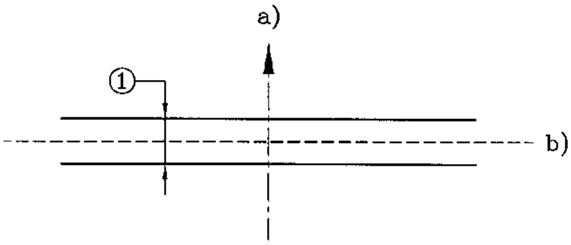
[1] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

1.3.8 Gap

1.3.8.1 Expansion joint gap (surface gap (1))

Opening (generally defined by one dimension) with a great length and a relatively small width in the road surface between sub-components of the expansion joint (perpendicular distance between two straight edges or planes):

a) Traffic direction
b) Longitudinal axis of the expansion joint.

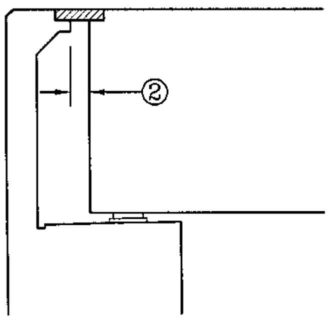


Note: In principle, the term gap is not restricted to straight border lines.

(See also EAD 120109-00-0107, Annex D, Clause D.2.2)

1.3.8.2 Bridge deck gap (structure gap (2))

Opening between two adjacent parts of the main structure, which is bridged by the expansion joint (distance between two structural elements) (See also EAD 120109-00-0107, Annex D, Clause D.2.2)



1.3.9 Kerb

The upstand which forms the boundary of the carriage way and the footpath (a vertical or inclined part of the joint which ensures continuity of the joint between road surface level and footway level).

1.3.10 Movement capacity

The range of the relative displacement between the extreme positions (e.g. maximum and minimum opening) of an expansion joint. (See also EAD 120109-00-0107, Annex D, Clause D.2.2)

1.3.11 Replaceability

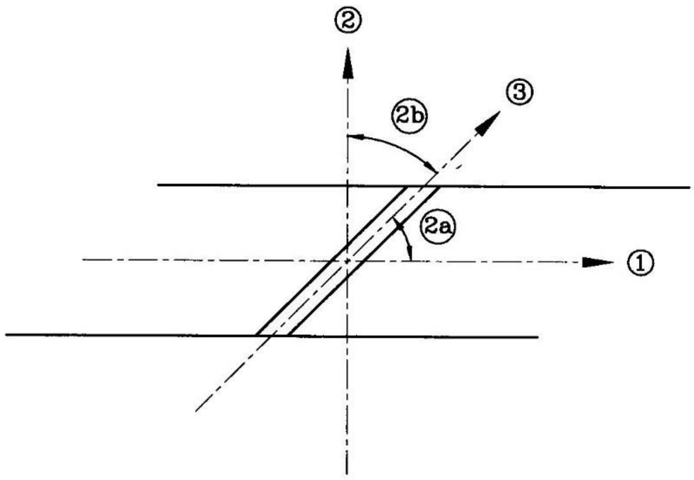
The ability to replace is given when a component, incorporated in the assembled expansion joint, can be exchanged during the intended working life of the expansion joint.

1.3.12 Skew angle (of the expansion joint)

Considering the existence of two interpretations of the skew of the bridge in Member States, it has two definitions:

a) the skew angle is the angle between the traffic direction and the longitudinal axis of the joint

b) the skew angle is the angle between the axis perpendicular to the road and the longitudinal axis of the joint



Legend

1: Road axis (in traffic direction)
2: Perpendicular to the road axis
2a and 2b: Skew angle
3: Longitudinal expansion joint axis

(See also EAD 120109-00-0107, Annex D, Clause D.2.2)

1.3.13 Void

An opening in the road surface (generally defined by two dimensions) with no load bearing capacity.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

All undated references to standards or to EADs in this chapter are to be understood as references to the dated versions listed in Clause 4.

2.1 Essential characteristics of the product

Table 1 shows how the performance of the cantilever expansion joint for road bridges is assessed in relation to the essential characteristics.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Watertightness	Clause 2.2.6	Description
7	Durability	Clause 2.2.7	Description
Basic Works Requirement 3: Hygiene, health and the environment			
8	Content, emission and/or release of dangerous substances	Clause 2.2.8	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
9	Ability to bridge gaps and levels in the running surface	Clause 2.2.9	Level
10	Skid resistance	Clause 2.2.10	Level
11	Drainage capacity	Clause 2.2.11	Level Description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

2.2.1 Mechanical resistance

Assessing the mechanical resistance of the cantilever expansion joint shall not lead to:

- collapse of the whole or a part of the works
- major deformations to an inadmissible degree
- damage by an event to an extent disproportionate to the original cause

Assessment shall be based on:

- Relevant load distribution and load model according to load model A or load model B below

- Actions (according to Clause 1.2.1.2.2) considered according to EAD 120109-00-0107, Annex D, Clause D.2.3 and D.2.4
- Safety factors used and assessment criteria according to Table 2

Calculations shall be done according to the conditions in the Eurocodes mentioned thereafter as far as relevant due to materials used and shall include information on calculation models used, whereas conditions and criteria defined thereafter shall be considered. Input from testing for calculation shall be introduced in the calculation, where relevant.

In case of testing, either in addition to or instead of calculation, as defined in the sub clauses thereafter, relevant components/assembled kit shall be referred to.

Assessment criteria used and based on the detailing thereafter shall be defined for the calculation.

In the ETA the assessment shall be stated in terms of description for the relevant product to be addressed (dimensions, materials, welds or bolted connections etc.).

Conditions for the assessment shall be stated in the ETA as far as relevant:

- Anchor forces for load distribution to the adjacent parts of the expansion joint
- the load models and load distribution model
- adjustment factors
- load factors
- combination factors

Whereas:

External loads on cantilever expansion joints are generated by traffic. Further loads on expansion joints may be generated as internal loads from imposed deformations or displacements or change of temperature of the joint itself.

Table 2 gives details of the assessment criteria for concerned limit states.

Table 2: Limit state and assessment criteria

Limit State	Limit State requirement	Remark
ULS	Static equilibrium Under imposed displacements of the main structure at ULS no contact between intersecting cantilevers shall occur	Assessment criteria given in this EAD are related to the defined design situations in EAD 120109-00-0107, Annex, Clause D.1. The cantilever expansion joint includes its anchoring system.
	No fatigue failure during the intended working life (see Clause 1.2.2 in this EAD). (Stress ranges below constant amplitude fatigue limit [CAFL] or cumulative damage assessment D<1,0).	
SLS	- No yielding of any part of the joint - Vertical deflections under loaded conditions of the expansion joint itself shall be less than 5 mm - No contact between intersecting cantilevers (see also Clause 2.2.4) - No separation of contact surfaces (i.e. all contact surfaces shall be under compression stress)	

SLS requirements are related to the design situations according to EAD 120109-00-0107, Annex D, Clause D.1.

ULS requirements are related to the design situations according to EAD 120109-00-0107, Annex D, Clause D.1.

The skew angle between the traffic direction and the longitudinal axis of the joint influences the load transfer and shall be considered in the assessment based on the technical documentation of the manufacturer. The skew angles have to be considered for the load distribution from the wheel to the joint. The most adverse situation is relevant. The skew angles which apply shall be stated in the ETA.

The actions, loads and combination in relation to the user and actions categories described in Clause 1.2.1.2 are given in EAD 120109-00-0107, Annex D, Clause D.2.

Assessment of the minimum operating temperature according to Clause 1.2.1.1 for metallic components of the kit is done according to EN 1993-1-10, Table 2.1.

For the load distribution the two load distribution models stated thereafter apply. The load distribution model is chosen by the manufacturer and is to be stated in the ETA.

Load distribution model A

Whereas the loads on the areas of zones 4 and 5 shall be added on the supporting area of zone 3, the load on zone 6 is not added to the load on expansion joint area A'.

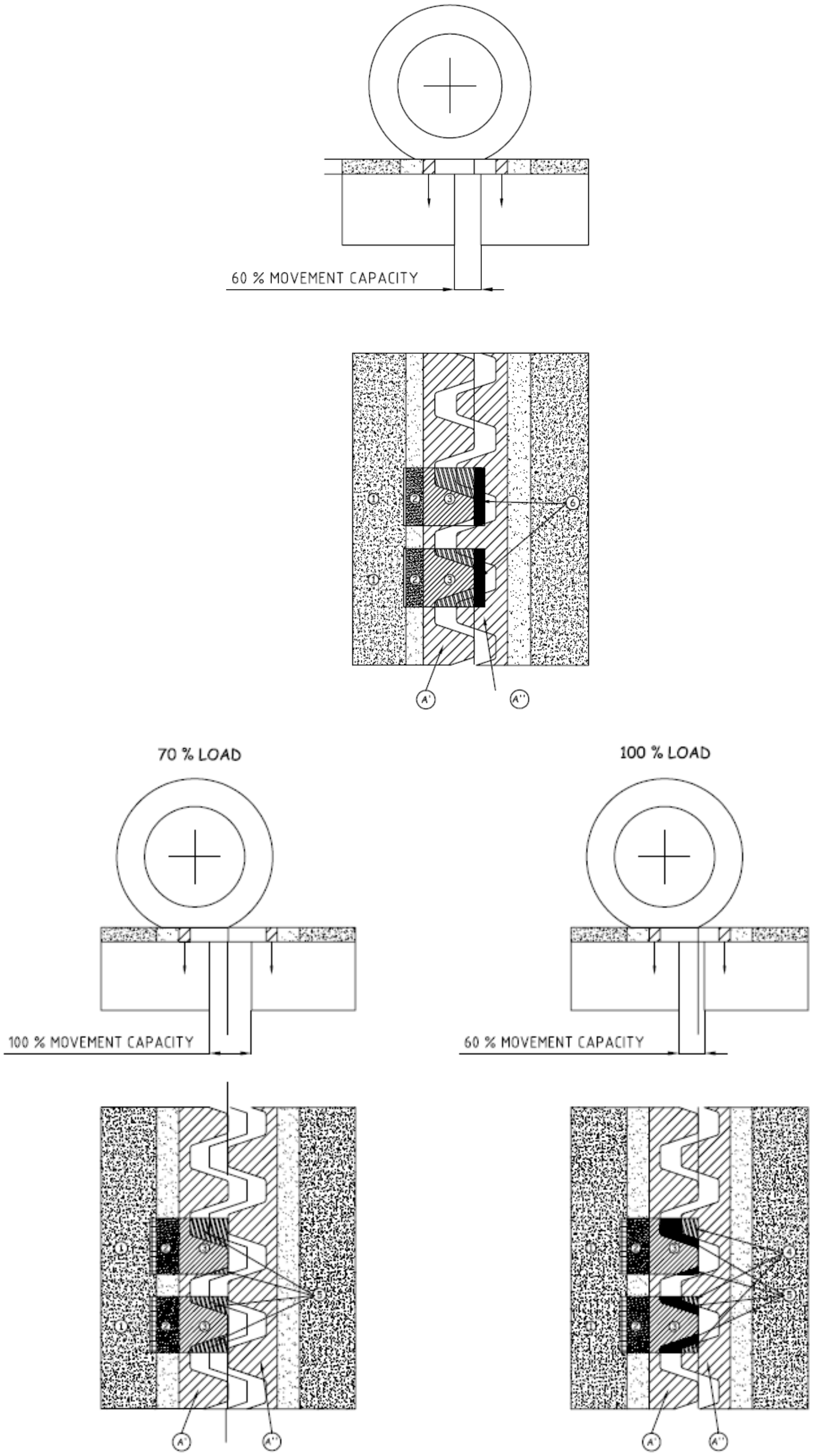


Figure 3: Principles of wheel load distribution model A for cantilever expansion joints

Key to Figure 3: Given in EAD 120109-00-0107, Annex D, Clause D.2.1.

Note: Zones 5' and 5" as given in EAD 120109-00-0107, Annex D, Clause D.2.1 are summarized in zone 5 for cantilever expansion joint load distribution model A.

Load distribution model B

The load distribution given in EAD 120109-00-0107, Annex D, Figure D.2, applies.

The mechanical resistance shall be assessed by means of calculation according to Clause 2.2.1.1, or calculation assisted by testing of components according to Clause 2.2.1.2. If calculation is not possible, calculation assisted by testing according to Clause 2.2.1.2 applies.

ULS assessment

For the assessment under ULS, the load shall be applied on the most adverse position of the cantilever expansion joint kit, related to the concerned ULS design situations given above considering to chosen load distribution model.

Note: Background for derivation of loads for $ULS_{EAD\ 120109\text{-}00\text{-}0107,\ Annex\ D}$ assessment: See Annex E.

SLS assessment

For the assessment under SLS, the load shall be applied on the most adverse position of the cantilever expansion joint kit, related to the concerned SLS design situations given above considering to chosen load distribution model.

Note: Background for derivation of loads for $SLS_{EAD\ 120109\text{-}00\text{-}0107,\ Annex\ D}$ assessment: See Annex E.

The following details used for assessment shall be described in the ETA (as far as relevant):

- Load distribution model used according to this clause in the EAD for the assessment
- Fulfilment of the requirements given in Table 2
- Anchor forces for load distribution to the adjacent parts of the expansion joint shall be stated in the ETA.
- the load models
- adjustment factors
- load factors
- combination factors

2.2.1.1 Calculations

Models used for calculation shall take into account relevant boundary conditions (e.g. actions, operating temperature, opening of the joint).

The partial factors γ_M shall be determined either:

- in accordance with Clause 6.3 of EN 1990 and,
- where relevant, using the recommended values given in the relevant Eurocode stated below, related to the materials.

In the ETA it shall be stated in terms of description that the product fulfils the mechanical resistance for the designs stated in the ETA and the partial factor γ_M values used for assessment shall be stated in the ETA.

Calculation of mechanical resistance, under the design situations stated in EAD 120109-00-0107, Annex D, Clause D.1, are following Eurocodes, in particular, those mentioned in Table 3:

- EN 1992-2
- EN 1993-1-4
- EN 1993-1-8
- EN 1993-1-10
- EN 1993-2
- EN 1994-2
- EN 1999-1-1
- EN 1999-1-4

Table 3: Guidance on assessment of mechanical resistance by calculation

Component	Eurocode	Relevant clauses (exemplary)
Anchorage system	EN 1992-1-1	6.5
Finger Plates	EN 1993-1-1	6.2.1
Substructure	EN 1993-1-1	6.2.1

Particular attention shall be paid to the pre-stress effects in the anchorage area between finger plate and base plate.

2.2.1.2 Calculation assisted by testing

Testing shall be done according to Annex B.

The specimen shall include the relevant part of the kit. The test loads and assessment criteria for the components to be tested shall be derived from a static calculation for the relevant design situations.

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.

The loads shall be derived from EAD 120109-00-0107, Annex D, Clause D.2.

2.2.2 Resistance to fatigue

The cantilever expansion joint shall have sufficient fatigue resistance with respect to its intended working life category according to Clause 1.2.2 in this EAD. The requirements given in Table 2 for ULS including vertical and horizontal loads apply.

The actions, loads and combinations are given in EAD 120109-00-0107, Annex D, Clause D.2.

Resistance against repeated movements of the main structure due to temperature and traffic is not relevant because they do not generate internal forces.

For the load distribution the conditions given in Clause 2.2.1 apply.

Resistance to fatigue shall be assessed by calculation, calculation assisted by testing or testing only. If calculation is not possible, component testing according to Clause 2.2.2.2 or full scale testing according to Claus 2.2.2.3 applies.

Assessment shall be carried out with 60 % of the maximum opening position.

For metallic parts, the unlimited fatigue life (CAFL according to Table 2) is characterized by 5 x 10^6 cycles at the maximum stress/strain interval in relation to $FLM1_{EJ}$.

CAFL for other materials shall be based on fatigue classifications derived from the relevant standards or testing.

For metallic parts, the limited fatigue life is characterized as a number of cycles (N_{obs} = 0,5 million/year) in relation to $FLM2_{EJ}$.

For other materials fatigue classifications shall be derived accordingly.

Testing can also be used to achieve more accurate classifications for common fatigue details.

The amplification factor $\Delta\varphi_{fat}$ = 1,3 given in EAD 120109-00-0107, Annex D, Clause D.2 may be reduced, considering unevenness effects (in the meaning of level differences of adjacent parts or structural elements) by more than 4 mm, based on dynamic testing (rollover test) according to Annex G.

Upswing effects shall be taken into account. The assessment of upswing effects shall be done in order to assess the concerned deflection and to determine the related forces to be taken into account. The fatigue assessment shall be done with a fatigue load amplitude of +100 % and -30 % (this means a fatigue load interval of 1,3 times the fatigue load in EAD 120109-00-0107, Annex D, Clause D.2) of the load defined in EAD 120109-00-0107, Annex D, Clause D.2. The amplification factor $\Delta\varphi_{fat}$ and the values for consideration of upswing effects may be reduced based on dynamic testing (rollover test) according Annex G in this EAD.

Upswing U_v and U_h shall be considered by factored vertical loads for fatigue assessment according the following equations based on equations [D.5] and [D.6] in EAD 120109-00-0107, Annex D, Clause D.2.3.3.2:

$$Q_{1k,fat,mod} = \Delta\varphi_{fat} \times Q_{1k} \times 0{,}7 \times (1 + U_v)$$

$$Q_{1lk,fat,mod} = 0{,}2 \text{ x } \Delta\varphi_{fat,h} \text{ x } Q_{1k} \text{ x } 0{,}7 \times (1 + U_h)$$

The following details used for assessment shall be described in the ETA (as far as relevant):

- Load distribution model used according to Clause 2.2.1 in the EAD for the assessment
- Fulfilment of the requirements given in Table 2
- Anchor forces for load distribution to the adjacent parts of the expansion joint shall be stated in the ETA.
- the load models
- adjustment factors
- load factors
- combination factors

2.2.2.1 Calculations

The partial factors for fatigue shall be determined either:

- in accordance with Clause 6.3 of EN 1990 or,
- where relevant, using the recommended values given in the relevant Eurocode stated below, related to the materials.

In the ETA it shall be stated in terms of description that the product fulfils resistance to fatigue for the designs stated in the ETA and the partial factor γ_M values used for assessment shall be stated in the ETA.

Calculation of resistance to fatigue, under the design situations stated in EAD 120109-00-0107, Annex D, Clause D.2 are following Eurocodes in particular those mentioned in Table 4:

- EN 1992-2
- EN1993-1-9
- EN 1993-2
- EN 1994-2
- EN 1999-1-3

Table 4: Guidance on assessment of resistance to fatigue by calculation

Component	**Eurocode**	**Relevant clauses (exemplary)**
Anchorage system	EN 1992-1-1 / EN 1994-2	6.8.7 / 6.8
Finger plates	EN 1993-2	9.5.1
Substructure	EN 1993-2	9.5.1

Note: $\Delta\sigma_{E2}$ according EN 1993-2, clause 9.5.1 relates to number of cycles equal to 2,0 x 10^6, while loads given by EAD 120109-00-0107, Annex D.2.3.3.2 for fatigue load model $FLM1_{EJ}$ relate to number of cycles equal to 5,0 x 10^6. Therefore stresses $\Delta\sigma_{FLM1,EJ}$ resulting from loads according EAD 120109-00-0107, Annex D.2.3.3.2 for fatigue load model $FLM1_{EJ}$ have to be increased by a factor of 1,356 (equal to $1/(2/5)^{1/3}$) to reach the equivalence level of $\Delta\sigma_{E2}$ = 1,356 x $\Delta\sigma_{FLM1,EJ}$.

For fatigue detail classifications EN 1993-1-9, clause 8 and EN 1993-2, clause 9 apply.

For calculation the load transfer and load introduction into the main structure shall be considered appropriately.

2.2.2.2 Calculation assisted by testing

Principles of calculation are given in Clause 2.2.2.1.

Component testing can be used for assessment of load bearing components representing the performance of the kit, depending on the design of the joint. Testing shall be done for the most adverse conditions according to Annex C.

The test loads and assessment criteria (see Annex C, Clause C.7) for the components to be tested shall be derived from a static calculation for the relevant design situations considering the principles of EAD 120109-00-0107, Annex D, Clause D.2.

2.2.2.3 Full-scale testing of the kit

The test specimen dimensions and the boundary conditions are selected in such a way that the structural behaviour complies with the behaviour in a real structure.

The loads shall be derived from EAD 120109-00-0107, Annex D, Clause D.2.

Full-scale testing on representative units may also be done as an equivalent alternative to calculation assisted by testing or calculation only.

The test method is given in Annex D.

2.2.3 Seismic behaviour

The assessment of seismic behaviour is referred to the categories given in EAD 120109-00-0107, Annex D, Clause D.2.4.2.3.

"Gap" according to EAD 120109-00-0107, Annex D, Table D.8, in this context reads "distance between the tooth ends of the opposing cantilever plates in opening position".

The movement capacity of a cantilever expansion joint does not allow movements in all directions, depending on the design of the finger shape. The limitations of movements in all directions shall be assessed by analysis of the technical file and given in the ETA.

The seismic behaviour shall be assessed by analysis of the design of the expansion joint in relation to the categories given in EAD 120109-00-0107, Annex D, Clause D.2.4.2.3 using the principles for the total design value of the displacement (dealt with in EAD 120109-00-0107, Annex D, Clause D.2.4.2.3.2) in the seismic design situation according to EN 1998-2, Clause 2.3.6.3.

The assessed category and the relevant indications according to EAD 120109-00-0107, Annex D, Table D.8 shall be stated in the ETA.

2.2.4 Movement capacity

The movement capacity of an expansion joint is the possibility to allow the displacement of the parts of the main structure under unloaded and loaded conditions as given in EAD 120109-00-0107, Annex D, Clause D.2.

The movement capacity shall be assessed for 3 directions: longitudinal, transversal and vertical.

The movement capacity, including the minimum opening in closed position, may either be defined by the manufacturer or is an outcome of the assessment.

The influence of displacement velocity and the temperature is not relevant for products according to this EAD.

For cantilever expansion joints with overlapping fingerplates it shall be assessed which bridge deck uplift is feasible, based on analysis of the technical file. The related value in relation to the opening position shall be stated in the ETA.

A minimum of overlapping as illustrated in Figure 4 is required and shall be stated in the ETA.

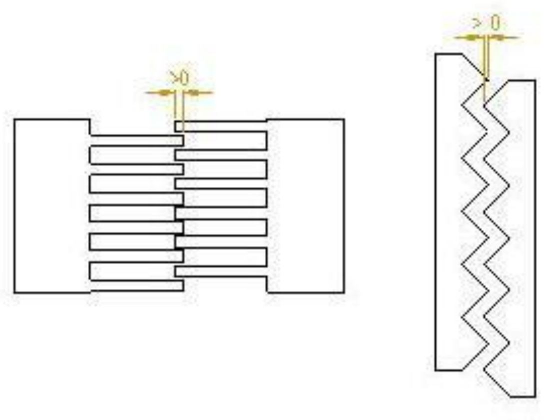


Figure 4: Rectangular and triangular cantilever minimum intersecting (dimensions in mm)

The movement capacity shall be assessed under unloaded and loaded conditions.

The assessment of the movement capacity under unloaded conditions is done by analysis of the technical file if no connection between the two sides of the joint is present (e.g. sealing element, gutter). Otherwise assessment method according to EAD 120109-00-0107, Annex D, Clause D.3 applies.

For the assessment of the movement capacity at SLS and ULS conditions the following values are provided by the manufacturer:

- at SLS minimum opening position between finger tips and the opposite element, minimum intersection
- at ULS minimum opening position between finger tips and the opposite element

The influence of longitudinal slopes shall be also assessed by kinematic check using the assessment methods given above.

For a sealing element without mechanical fixing in edge profiles (“compression seals”), the effect of creep and/or relaxation of the sealing element shall be considered by a pre-compression time of 24 h at the minimum opening before starting the test.

The results of the assessment of the movement capacity for the concerned directions shall be stated in the ETA, whereas the skew angle for related combinations shall be taken into account. The reaction forces (where relevant) shall be stated in the ETA. The minimum opening shall be stated in the ETA.

2.2.5 Cleanability

The ability for cleanability shall be assessed based on the design of the cantilever expansion joint.

Cleanability is assessed by means of accessibility (e.g. dismountable finger plates) to the relevant part of the expansion joint (gutter/sealing element).

The following results of assessment apply: Cleanable; Not cleanable.

Cleanable means that debris can be removed manually.

Not cleanable means it cannot be cleaned manually for all opening positions.

For cantilever expansion joints without drainage devices (gutter) or sealing element the assessment of cleanability is not relevant.

2.2.6 Watertightness

It shall be assessed whether the main structure and where relevant the sub-components of the cantilever expansion joint under the running surface are protected from water and its chemical contents.

Watertightness of cantilever expansion joints is achieved either by a sealing element or by a sub-surface drainage system (gutter).

For the assessment of the watertightness of the cantilever expansion joint including a sealing element, the test method is described in EAD 120109-00-0107, Annex D, Clause D.4.

For the test method according to EAD 120109-00-0107, Annex D, the value of opening used for testing is defined by the worst condition which is the minimum contact pressure between the sealing element and it’s fixing.

For a sealing element without mechanical fixing in edge profiles (“compression seals”) the effect of creep and/or relaxation of the sealing element shall be considered by a pre-compression time of 24 h at the minimum opening before starting the test.

The result of the assessment of the watertightness (moisture under the joint) shall be stated in the ETA, whereas the following results of assessment apply: Watertight; Not watertight.

Where watertightness is ensured by a sub-surface drainage system (gutter) EAD 120109-00-0107, Annex D, Clause D.4 does not apply. The durability of the gutter and its drainage capacity are considered to be the crucial aspects and have to be assessed. For durability aspects of the gutter, the concerned requirements and assessment methods, given in Clause 2.2.7, apply. For the assessment of the drainage capacity, Clause 2.2.11 applies.

The result of the assessment of the watertightness shall be stated in the ETA, whereas the following results of assessment apply: Watertight; Not watertight.

In addition:

Where a watertight connection between the waterproofing system of the main structure and the cantilever expansion joint is foreseen as component of the expansion joint, for the assessment according to EAD 120109-00-0107, Annex D, the last paragraph in Clause D.4.4.1 applies in addition accordingly.

The type of the connection shall be described in the ETA.

The result of the assessment of the watertightness (moisture under the joint) shall be stated in the ETA, whereas the following results of assessment apply: Watertight; Not watertight.

2.2.7 Durability

2.2.7.1 Corrosion

For metallic surfaces of components, the climatic classification in accordance with EN ISO 9223 (see Clause 1.1) with respect to the intended use of the product is taken into account.

It shall be assessed whether the corrosion protection layout for the concerned kit conforms with the conditions given in the scope of the EAD (possibly using the technical documentation of the manufacturer).

Galvanic corrosion is not assessed.

For use of aluminium for finger plate the conditions in Clause 1.1 shall be assessed based on manufacturer’s technical documentation.

Based on the manufacturer’s technical documentation for the corrosion protection system, the durability class in relation to the corrosivity class according to the standards given in Clause 1.1 shall be given in the ETA.

2.2.7.2 Chemicals

Assessment of the resistance to de-icing salts for sealing element/gutter made of elastomer shall be done according to ISO 1817 (immersion for 14 days 23 °C, 4 % sodium- chloride solution or equivalent).

The sealing element/gutter shall show no decrease of hardness exceeding 5 Points and no increase of volume exceeding 10 %.

2.2.7.3 Loss of performance due to ageing resulting from temperature and ozone

The performance of the cantilever expansion joint shall not be affected by ageing. For the product according to this EAD this applies to the sealing element/gutter made of elastomer or gutter made of plastics.

2.2.7.3.1 Resistance to ageing resulting from temperature

To assess the sensitivity of the sealing element/gutter made of elastomer to elevated temperature, the material shall be subjected to test method ISO 188 (Method A). The minimal conditions of exposure are the following: 14 days at a temperature of 70 °C.

The hardness before and after ageing is measured according to ISO 48-2 or ISO 48-4 respectively, the tensile strength and the elongation at break are measured according to ISO 37.

To assess the sensitivity of the gutter made of plastics to elevated temperature, the material shall be subjected to test method EN ISO 2578 and EN ISO 11403-3, clause 6.5 respectively at +50°C.

The hardness before and after ageing is measured according to EN ISO 2039-1, the tensile strength and the elongation at break are measured according to ISO 527-2.

After ageing of the elastomer, the change in hardness and the change of tensile properties of the aged specimen shall be within:

Hardness ≤ + 7 points

Tensile strength ≥ -20%

Elongation at break ≥ -30%

For plastics, assessment shall be done in equivalence to the values for elastomers.

These values apply for all working life categories.

For the assessment of the resistance of the sealing element/gutter to low temperatures, the brittleness test according to ISO 812, Method B applies.

With respect to the operating temperature condition, according to Clause 1.2.1, for the execution of the brittleness test of the sealing element/gutter made of elastomer the following temperatures apply:

-25 °C for operating temperatures down to -20 °C,

-40 °C for operating temperature equal to -30 °C,

-55 °C for operating temperature equal to -40 °C.

With respect to the operating temperature condition, according to Clause 1.2.1, for the execution of the brittleness test of the gutter made of plastics the following temperatures apply:

-25 °C for operating temperature down to -20 °C,

-40 °C for operating temperature equal to -30 °C and -40 °C.

2.2.7.3.2 Resistance to ageing resulting from ozone

To assess the sensitivity to ozone of the sealing element/gutter made of elastomer, the material shall undergo a test. The test specimen shall be assessed according to test method ISO 1431-1 (Test procedure A: static condition).

The test conditions are the following: 72 hours of exposure at the temperature of 40 °C, with an ozone concentration of 50 pphm. The test specimen is submitted to 20 % of elongation.

After the test no cracks shall occur.

2.2.8 Content, emission and/or release of dangerous substances

The performance of the product related to the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer[2] after identifying the release scenarios (in accordance with EOTA TR 034) taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The identified intended release scenario for this product and intended use with respect to dangerous substances is:

S/W2: Product with indirect contact to soil, ground- and surface water

2.2.8.1 Leachable substances

For the intended use covered by the release scenario S/W2 the performance of the sealing element made of elastomer or gutter made of elastomer or plastics concerning leachable substances has to be assessed. A leaching test with subsequent eluate analysis must take place, each in duplicate. For the leaching tests of the sealing element made of elastomer or gutter made of elastomer or plastics EAD 120109-00-0107, Annex D, Clause D.6 applies.

2.2.9 Ability to bridge gaps and levels in the running surface

2.2.9.1 Allowable surface gaps and voids

The maximum dimensions of the gaps and voids of the joint at the surface level depend on the three user categories.

For the range of the skew angle β (see Figure 5) to be assessed for all user categories the following requirements shall be met and the chosen approach according to Clause 1.3.12 shall be stated in the ETA.

For vehicles and cyclists categories the expansion joint shall not allow a vertical displacement of more than the radius of a 10,0 cm diameter sphere placed anywhere on the running surface level.

a) Vehicles

The expansion joint shall not allow a vertical displacement of 1,0 cm or more of the following bodies, in conjunction with the traffic direction:

- a horizontal prism with plan dimensions 10,0 cm by 20,0 cm placed horizontally anywhere and in any direction,
- a horizontal prism with plan dimensions 6,5 cm by 22,0 cm placed horizontally anywhere with a deviation from the traffic direction α of -20° to +20°,

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2 The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011).

The manufacturer is **not** obliged:

- to provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- to provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS.

Any information provided by the manufacturer regarding the chemical composition of the products may not be distributed to EOTA or to TABs.

- a horizontal prism with plan dimensions 4,5 cm by 35,0 cm placed horizontally anywhere with a deviation from the traffic direction α of -20° to +20°.

b) Cyclists

The expansion joint shall not allow a vertical displacement of 1,0 cm or more of the following bodies, in conjunction with the traffic direction:

- a horizontal prism with plan dimensions 2,0 cm by 22,0 cm placed horizontally everywhere with a deviation from the traffic direction α of -20° to +20°,
- a horizontal prism with plan dimensions 10,0 cm by 20,0 cm placed horizontally everywhere and in any direction.

The design of the expansion joint for the carriageway can be adapted by special measures to fulfil the above requirement (see Clause 1.1).

c) Pedestrians

The expansion joint shall not allow a vertical displacement of 2,0 cm or more of a disk with a diameter of 8,0 cm placed horizontally everywhere.

Assessment shall be carried out by analysis of the technical file and, when needed, by use of measurements tools given above.

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

The definition of the skew angle used for the assessment shall be stated in the ETA (see Clause 1.3.12 for different possibilities).

The design of the expansion joint for the carriageway can be adapted by special measures to fulfil the above requirement (see Clause 1.1).

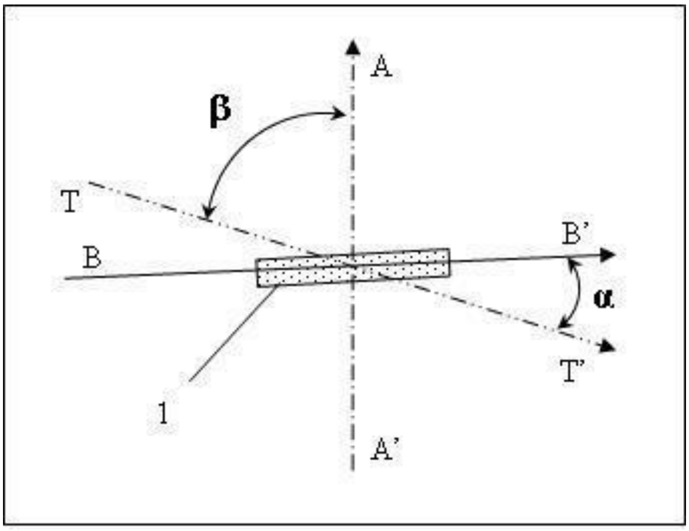


Figure 5: Assessment of the allowable gaps and voids

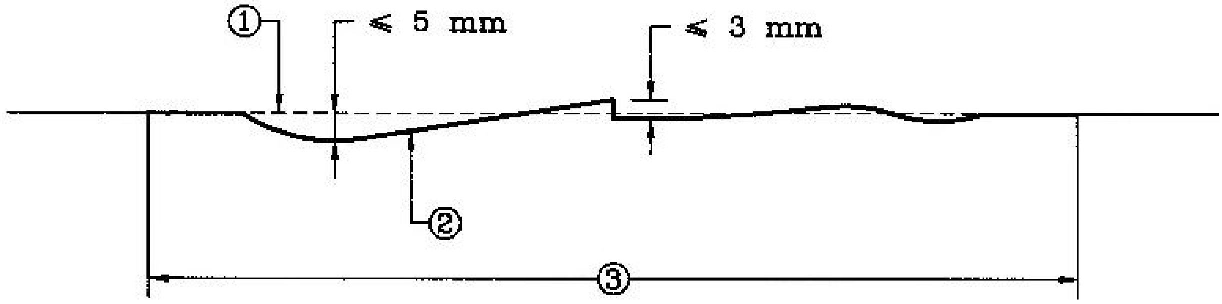
Key to Figure 5:

TT': Traffic direction
AA': Expansion joint axis
BB': Orientation of the measuring prism
1: Measuring prism
α: Deviation from traffic direction
β: Skew angle

2.2.9.2 Level differences in the running surface

Without any imposed horizontal deformations and in unloaded condition the difference in the levels of the running surface of the joint from the ideal connection line between the two adjacent pavements in the traffic direction shall not be greater than 5 mm. Steps shall not be greater than 3 mm (without considering surface texture and discontinuities due to gaps and voids). See Figure 6.

This rule is applied in a horizontal position.



① Ideal connection line

② Running surface of the joint

③ Expansion joint

Note: The level differences could be in the opposite direction.

Figure 6: Example of level differences in the running surface under unloaded conditions

Assessment for the unloaded condition shall be undertaken on the basis of analysis of the technical file and drawings.

Intersecting teeth with sloping surfaces shall not cause effective level differences in the traffic direction exceeding the values given in Figure 6.

The maximum dimension of steps and the difference of the running surface levels shall be stated in the ETA.

For the assessment of level differences in the running surface under loaded conditions the following applies:

For user category “Vehicles“ the intersecting teeth with sloping surfaces (e.g. chamfering at the tips of the fingers) shall not cause effective level differences in the traffic direction greater than 12 mm in total at SLS level.

For non-sloping surfaces the effective steps in the traffic direction shall not exceed 5 mm in total.

For loaded conditions (loading of the joint itself) assessment shall be done according to Clause 2.2.1.

Under loaded conditions, the maximum vertical deflection, according to the assessment by testing or calculation, shall be stated in the ETA.

2.2.10 Skid resistance

This essential characteristic only applies for cantilever expansion joints with flat running surfaces larger than 150 mm x 150 mm square and with surface textures less than ± 1,2 mm (possibly met by special design, e.g. chequered plate). This applies to the carriageway and footpath.

The skid resistance of the cantilever expansion joint shall be assessed by the portable skid resistance pendulum tester as described in EN 13036-4, clause 9.2 using the 57 Rubber slider for carriageways and the 96 rubber slider for footpaths. For both, the normal slider width of 76.2 mm shall be used.

The PTV values assessed shall be stated in the ETA.

2.2.11 Drainage capacity

Where relevant due to the cantilever expansion joint kit is including a drainage device (gutter), the drainage capacity shall be assessed by calculation using the following formula based on EN 12056-3:

$$Q_0 = k_0 * D^2 * h^{0.5} /15000 \text{ [l/s]}$$

Where:
k_0 = 1,0 for free down pipe and 0,5 for downpipes with dirt filter [-]
D = Flow diameter [mm]
h = Pressure height (depending on planned target water height) [mm]

The value for Q_0 shall be stated in the ETA.

Where relevant, due to the cantilever expansion joint kit is including a drainage device according to EAD 120109-00-0107, Annex D, Figure D.11, the drainage capacity shall be assessed according to the assessment method described in EAD 120109-00-0107, Annex D, Clause D.5.

The drainage capacity in mm³/sec together with definition of the porous pavement as defined according to the assessment method in EAD 120109-00-0107, Annex D, Clause D.5, shall be stated in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Decision 2001/19/EC

The system is: 1

The performance of any kit component which is obtained from a component manufacturer and is CE marked on the basis of a hEN or an EAD will, (for the purposes of verification of constancy of performance) be considered to be the performance declared by the component manufacturer in his DoP. The component does not need to be re-assessed regarding this performance aspect.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 5.

In case of components manufactured by separate manufacturers, the FPC as indicated in the Table below is related to relevant documentation provided by the manufacturer of the expansion joint.

Table 5 Control plan for the manufacturer; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Factory production control (FPC) including testing of samples taken at the factory in accordance with a prescribed test plan					
Sealing element/gutter made of elastomer					
1	Density	ISO 2781	Laid down in the control plan	According to the relevant standard.	Each batch/each lot (sequence of batches with identical composition), or certificate type 3.1 according to EN 10204 at each delivery.
2	Hardness	ISO 48-2 or ISO 48-4	Laid down in the control plan	According to the relevant standard.	Each batch/each lot (sequence of batches with identical composition), or certificate type 3.1 according to EN 10204 at each delivery.
3	Tensile strength	ISO 37	Laid down in the control plan	According to the relevant standard.	Each batch/each lot (sequence of batches with identical composition), or certificate type 3.1 according to EN 10204 at each delivery.
4	Elongation at break	ISO 37	Laid down in the control plan	According to the relevant standard.	Each batch/each lot (sequence of batches with identical composition), or certificate type 3.1 according to EN 10204 at each delivery.
5	Tear resistance	ISO 34-1	Laid down in the control plan	According to the relevant standard.	Every three months
6	Compression set	ISO 815-1 24 h and 70 °C constant deflexion 25 %	Laid down in the control plan	According to the relevant standard.	Once per year
7	Thermogravimetric analysis (TGA)	ISO 9924-1 or ISO 9924-3	Laid down in the control plan	According to the relevant standard.	Once per year
Gutter made of plastics					
1	Relevant parameters laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each delivery certificate type 2.1 according to EN 10204
Gutter made of steel/stainless steel					
1	Resistance to corrosion	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each delivery certificate type 3.1 according to EN 10204

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Fingerplates made of steel/stainless steel/cast iron/cast steel					
1	Elasticity limit $f_{0,2k}$ at 0,2 %	EN 10025 or EN 10088 or ISO 1083 (relevant part laid down in control plan)	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
2	Tensile strength				
3	Elongation at break				
4	Energy absorption (Charpy V test) (if dynamically loaded)				
5	Chemical composition				
6	Ductility				
6	Corrosion protection: - Assessment of the thickness and the continuity of the layer - Surface characteristics before corrosion protection application (roughness, cleanliness) - Drying time	Laid down in the control plan			Each batch or every assembled expansion joint
Fingerplates made of aluminium / kerbs or cover plates made of aluminium					
1	Elasticity limit at 0,2 %	EN 755-2 or EN 485-2	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
2	Tensile strength				
3	Elongation at break				
4	Energy absorption (Charpy V test) (if dynamically loaded)				
5	Chemical composition				
6	Ductility				
7	Stress-strain				

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Kerbs/cover plates made of steel/stainless steel					
1	Elasticity limit $f_{0,2k}$ at 0,2 %	EN 10025 or EN 10088 (relevant part laid down in control plan)	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
2	Tensile strength				
3	Elongation at break				
4	Chemical composition				
5	Corrosion protection	Laid down in the control plan			
Components for support structure and anchorage made of steel/stainless steel					
1	Elasticity limit $f_{0,2k}$ at 0,2 %	EN 10025 or EN 10088 (relevant part laid down in control plan)	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
2	Tensile strength				
3	Elongation at break				
4	Chemical composition				
5	Corrosion protection	Laid down in the control plan			
Reinforcement bars/loops for support structure made of steel					
1	Elasticity limit $f_{0,2k}$ at 0,2 %	EN 10025 or EN 10088 (relevant part laid down in control plan)	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
2	Tensile strength				
3	Ductility				
4	Weldability				
5	Bendability				
6	Bond property				

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Welded dowels for dynamically loaded components					
1	Relevant material parameters (laid down in the control plan) and welding	EN ISO 13918	Laid down in the control plan	According to the relevant standard.	Certificate type 3.1 according to EN 10204 at each delivery.
Bolts, nuts and washers					
1	According to the relevant technical specification.	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	DoP, where relevant, or certificate type 3.1 according to EN 10204 at each delivery or confidence achieved by sufficient samples testing
2	Corrosion protection	E.g. EN ISO 10684	Laid down in the control plan	Laid down in the control plan	Each delivery
Bonded anchor (steel +resin mortar/grout)					
1	According to the relevant technical specification.	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	DoP, where relevant, or certificate type 3.1 according to EN 10204 at each delivery or confidence achieved by sufficient samples testing
Elements of anchorage (anchor bar, grout, resin mortar, …)					
1	According to the relevant technical specification.	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	DoP, where relevant, or certificate type 3.1 according to EN 10204 at each delivery or confidence achieved by sufficient samples testing. For secondary elements, certificate type 2.2 according to EN 10204, at each delivery.

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control *)
Drainage device (defined in EAD 120109-00-0107, Annex D, Figure D.11) made of stainless steel or aluminium					
1	Relevant parameters laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan
Finished product					
Finger plates					
1	Dimensions, thickness	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each part
2	Corrosion protection including layer thickness measurement				
Support structure, anchorage devices and kerb elements					
1	Surface characteristics, manufacturing tolerances	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each part
2	Weld method statements, weld method qualifications				
3	Corrosion protection, including layer thickness measurement				
Gutter/sealing element					
1	Dimensional check	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each delivery
General assembly					
1	Conformity to the specification drawings e.g. preset, corrosion protection, correct elements, dimensions, pre assembly.	Laid down in the control plan	Laid down in the control plan	Laid down in the control plan	Each assembled product.

*) In case of irregular production it is possible to agree different frequency between manufacturer and notified body.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for cantilever expansion joints for road bridges are laid down in Table 6.

The performance of the components covered by hENs regarding those characteristics declared already by the component manufacturers in their DoP should not be assessed when the product (the kit) will be assessed by the TAB. The performance of those components for the purpose of issuing the ETA will be considered to be the performance declared by the manufacturers of the component. TABs may only assess the performance of the components only for essential characteristics not declared by the manufacturer of the component in his DoP.

Table 6 Control plan for the notified body; cornerstones

No	Subject/type of control *(product, raw/constituent material, component - indicating characteristic concerned)*	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the expansion joint.	As defined in the control plan.	As defined in the control plan.	As defined in the control plan.	1
Continuous surveillance, assessment and evaluation of factory production control					
2	Continuous surveillance, assessment and evaluation of factory production control carried out by the manufacturer (parameters according to Table 5 of this EAD).	As defined in the control plan.	As defined in the control plan.	As defined in the control plan.	At least once a year

4 REFERENCE DOCUMENTS

The following documents, in whole or in part, are normatively referenced in this European Assessment Document and are indispensable for its application. Only the specified edition applies.

EN 485-2:2016+A1:2018	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 755-2:2016	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 2: Mechanical properties
EN 1990:2002 + A1:2005 + A1:2005/AC:2010	Eurocode: Basis of structural design
EN 1991-1-5:2003 + AC:2009	Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions
EN 1991-2:2003 + AC:2010	Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges
EN 1992-1-1:2004 + AC:2010	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1992-2:2005 + AC:2008	Eurocode 2: Design of concrete structures — Part 2: Concrete bridges — Design and detailing rules
EN 1993-1-1:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1993-1-4:2006 + A1:2015	Eurocode 3: Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
EN 1993-1-8:2005 + AC:2009	Eurocode 3: Design of steel structures — Part 1-8: Design of joints
EN 1993-1-9:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-9: Fatigue
EN 1993-1-10:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
EN 1993-2:2006 + AC:2009	Eurocode 3: Design of steel structures - Part 2: Steel Bridges
EN 1994-2:2005 + AC:2008	Eurocode 4: Design of composite steel and concrete structures — Part 2: General rules and rules for bridges
EN 1998-2:2005 + A1:2009 + A2:2011 + AC:2010	Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges
EN 1999-1-1:2007 + A1:2009 + A2:2013	Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules
EN 1999-1-3:2007 + A1:2011	Eurocode 9: Design of aluminium structures — Part 1-3: Structures susceptible to fatigue
EN 1999-1-4:2007 + AC:2009	Eurocode 9: Design of aluminium structures — Part 1-4: Cold-formed structural sheeting
EN 10025-2:2004	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
EN 10025-3:2004	Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
EN 10025-4:2004	Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

EN 10025-5:2004	Hot rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
EN 10025-6:2004 + A1:2009	Hot rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
EN 10088-2:2014	Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
EN 10088-3:2014	Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes
EN 10088-4:2009	Stainless steels - Part 4: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
EN 10088-5:2009	Stainless steels - Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes
EN 10204:2004	Metallic products - Types of inspection documents
EN 12056-3:2000	Gravity drainage systems inside buildings - Part 3: Roof drainage, layout and calculation
EN 13036-4:2011	Road and airfield surface characteristics - Test methods - Part 4: Method for measurement of slip/skid resistance of a surface - The pendulum test
EN ISO 2039-1:2003	Plastics - Determination of hardness - Part 1: Ball indentation method
EN ISO 2081:2018	Metallic and other inorganic coatings - Electroplated coatings of zinc with supplementary treatments on iron or steel
EN ISO 2578:1998	Plastics - Determination of time-temperature limits after prolonged exposure to heat
EN ISO 3506-1:2009	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs
EN ISO 9223:2012	Corrosion of metals and alloys - Corrosivity of atmospheres - Classification, determination and estimation
EN ISO 10684:2004 + AC:2009	Fasteners - Hot dip galvanized coatings
EN ISO 11403-3:2014	Plastics - Acquisition and presentation of comparable multipoint data - Part 3: Environmental influences on properties
EN ISO 12944-1:2017	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction
EN ISO 13918:2018	Welding - Studs and ceramic ferrules for arc stud welding
EN ISO 14713-1:2017	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance
ISO 34-1:2015	Rubber, vulcanized or thermoplastic - Determination of tear strength - Part 1: Trouser, angle and crescent test pieces
ISO 37:2017	Rubber, vulcanized or thermoplastic - Determination of tensile stress-strain properties
ISO 48-2:2018	Rubber, vulcanized or thermoplastic - Determination of hardness - Part 2: Hardness between 10 IRHD and 100 IRHD

ISO 48-4:2018	Rubber, vulcanized or thermoplastic - Determination of hardness - Part 4: Indentation hardness by durometer method (Shore hardness)
ISO 188:2011	Rubber, vulcanized or thermoplastic - Accelerated ageing and heat resistance tests
ISO 527-2:2012	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics
ISO 812:2017	Rubber, vulcanized or thermoplastic - Determination of low-temperature brittleness
ISO 815-1:2014	Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures
ISO 1083:2018	Spheroidal graphite cast irons - Classification
ISO 1431-1:2012	Rubber, vulcanized or thermoplastic - Resistance to ozone cracking - Part 1: Static and dynamic strain testing
ISO 1817:2015	Rubber, vulcanized or thermoplastic - Determination of the effect of liquids
ISO 2781:2018	Rubber, vulcanized or thermoplastic - Determination of density
ISO 9924-1:2016	Rubber and rubber products - Determination of the composition of vulcanizates and uncured compounds by thermogravimetry - Part 1: Butadiene, ethylene-propylene copolymer and terpolymer, isobutene-isoprene, isoprene and styrene-butadiene rubbers
ISO 9924-3:2009	Rubber and rubber products - Determination of the composition of vulcanizates and uncured compounds by thermogravimetry - Part 3: Hydrocarbon rubbers, halogenated rubbers and polysiloxane rubbers after extraction
EOTA TR034	General BWR3 Checklist for EADs/ETAs - Dangerous substances
EAD 120109-00-0107	Nosing expansion joints for road bridges

ANNEX A – EXAMPLES OF FINGER SHAPES FOR CANTILEVER EXPANSION JOINTS

This annex does not provide any design. It only illustrates different shapes of cantilevers.

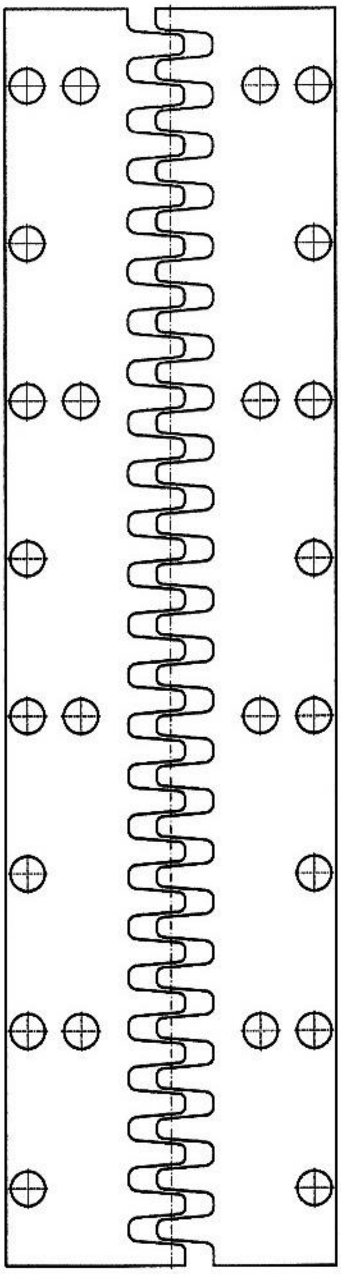


Figure A.1

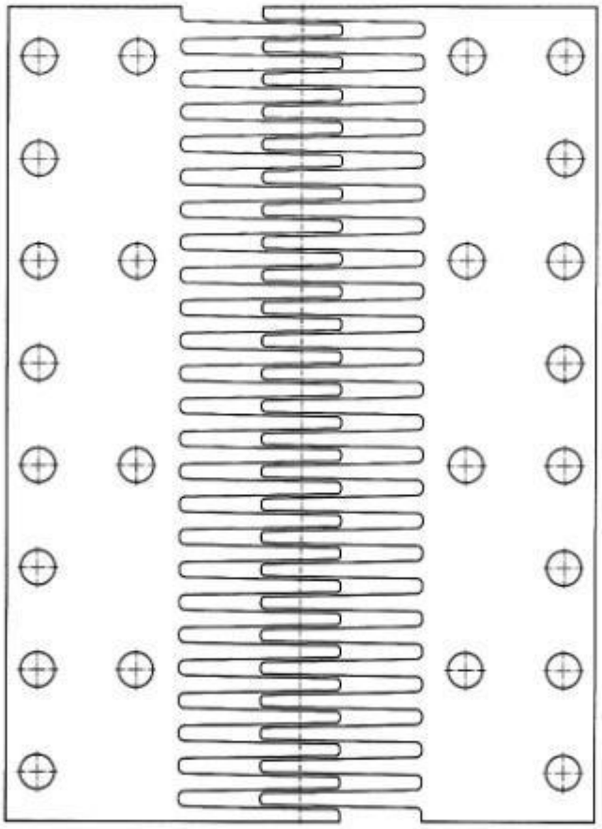


Figure A.2

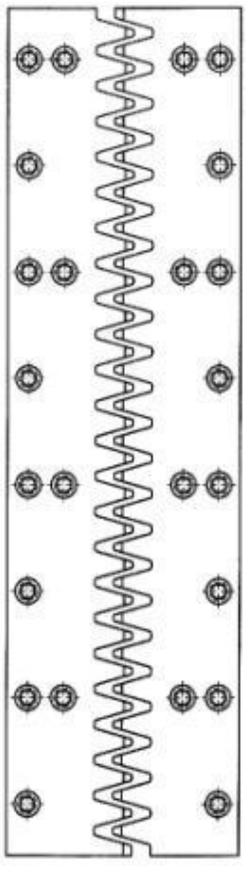


Figure A.3

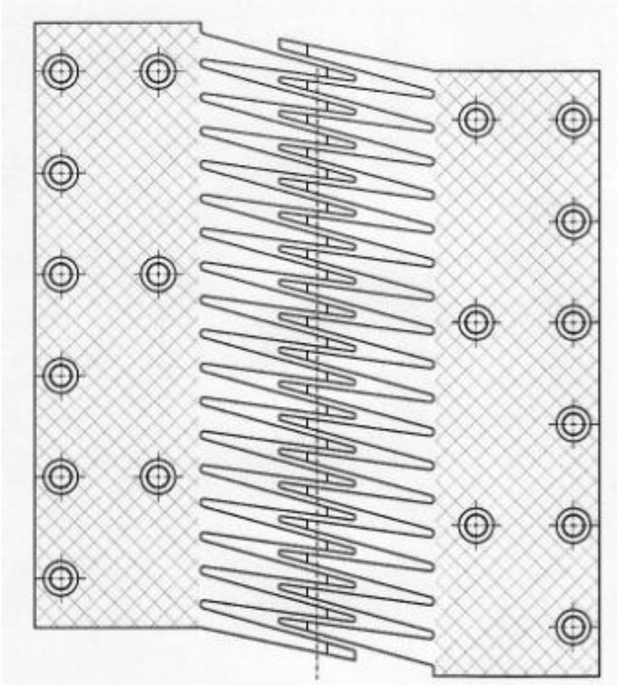


Figure A.4

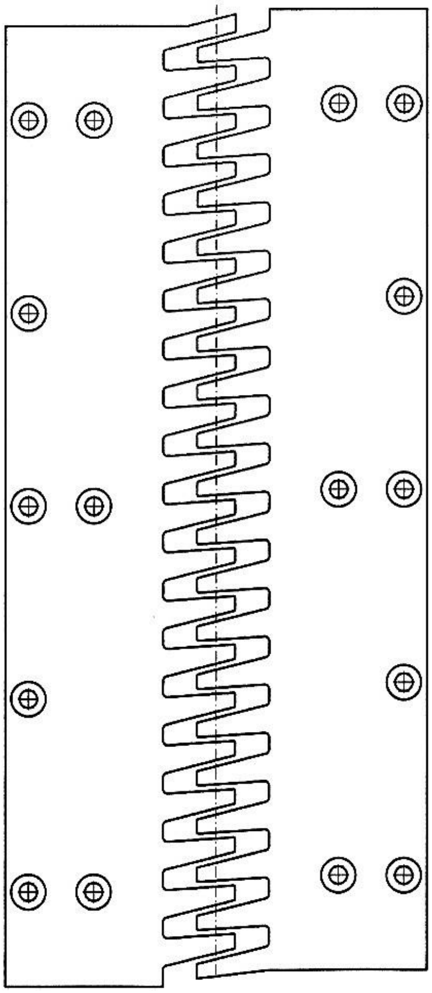


Figure A.5

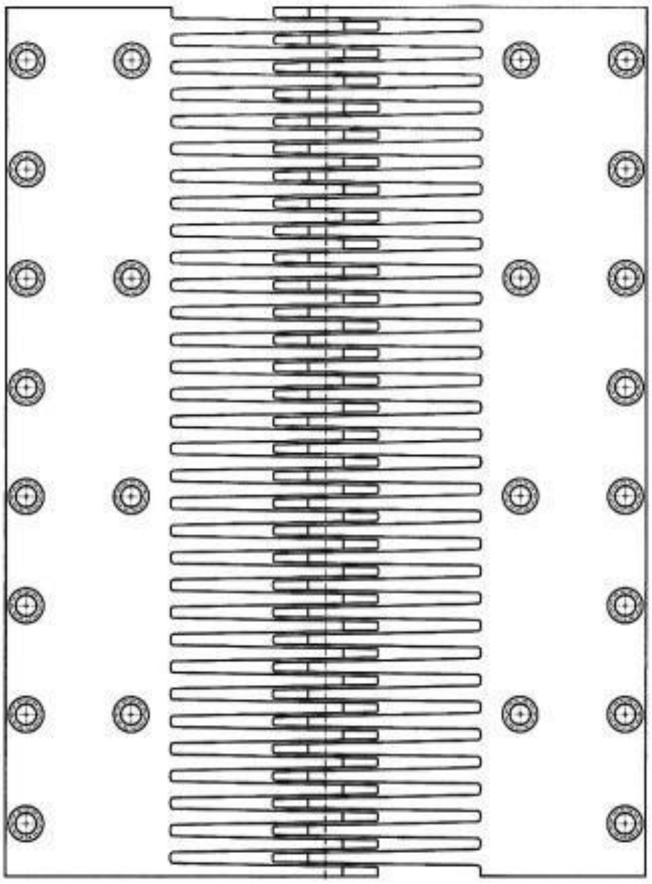


Figure A.6

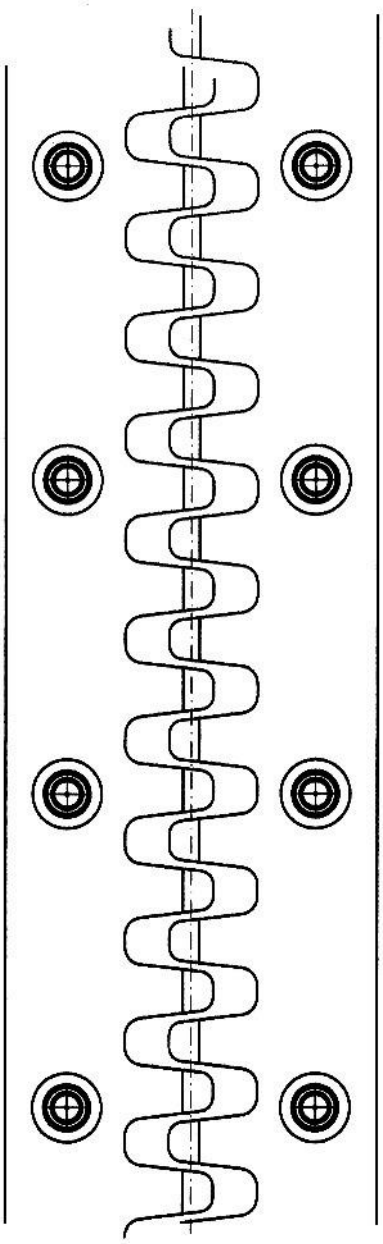


Figure A.7

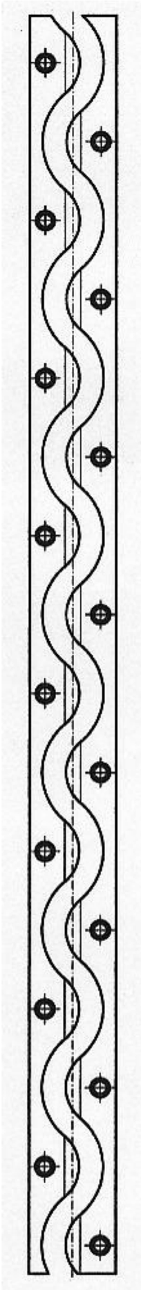


Figure A.8

ANNEX B – MECHANICAL RESISTANCE TEST METHOD - REPRESENTED BY FULL-SCALE COMPONENT TEST

B.1 – SCOPE

This annex describes the method for assessing the mechanical resistance of parts of the kit in one testing procedure.

B.2 – PRINCIPLES

The principle of this test is to apply a load, derived from calculations, representing the design situations and to investigate the behaviour for the design situations at SLS and ULS. The test results will be used to assess the requirements according to Clause 2.2.1.

In the case of calculation assisted by testing the samples to be tested shall cover the relevant part of the kit according to Clause 2.2.1. For each part at least three specimens shall be tested. In case of a range of products, the number of test specimens is defined in Clause B.5.

B.3 – SAMPLES AND PREPARATION OF SPECIMENS

The test specimens shall correspond to the relevant part of the design including all features of the components.

The preparation of the test specimen is under the responsibility of the manufacturer.

B.4 - LOAD ARRANGEMENTS

B.4.1 TEST LOADS

The concerned test loads for the concerned design situations at SLS and ULS shall be derived from the relevant design situations in accordance with Clause 2.2.1, considering the guidance given in Annex E.

B.4.2 APPLICATION OF TEST LOAD

The application of loads shall take into account the representative introduction of the loads into the component and into the substructure.

B.5 - TESTING ARRANGEMENT

The test conditions shall represent an appropriate modelling of the built-in conditions.

If there is a range with the same type, then take one test at each border of the range and one test in the middle of the range.

B.6 - EXECUTION OF THE TEST

The execution shall cover the SLS and ULS design situation derived according to Clause B.4.1.

B.6.1 TEST CONDITIONS

The test shall be carried out at ambient temperature.

The load shall be increased and decreased respectively with a rate within a range of 2,5 kN/sec to 5,0 kN/sec.

B.6.2 TEST PROCEDURES

B.6.2.1 Test procedures for SLS design situation

The load shall be applied until the relevant SLS load level.

At that SLS-load level the following assessments shall be carried out:

- visual inspection during applying the load
- measurement and continuous recording of deformations
- observations with respect to uplift

Total removal of the load:

- after removal of the test load remaining deformations shall be recorded
- visual inspection

B.6.2.2 Procedure for ULS design situation

The load shall be applied until ULS load level and at 100 % ULS level it shall be maintained for a period of three minutes.

At 100 % of ULS-load level the following assessments shall be carried out:

- Visual inspection for identifying the failure modes, if any

Note: After passing the ULS test, loading may be further increased until collapse if the equipment allows and to identify the post critical behaviour.

B.7 - EXPRESSION OF TEST RESULTS

The following phenomena shall be monitored and recorded (using figures and/or graph(s) as applicable) for all test procedures:

- Applied loads (kN) and loading rate
- Values of the deflections (e.g. graphs and/or tables)
- Exceptional behaviour, e.g. excessive deformations (e.g. photographs and description)
- Failure mode (characteristic of failure, failure progress at ULS, location, uplift) shall be described

B.8 - TEST REPORT

The test report shall refer to this annex and shall include at least the following:

- Name of the manufacturer and production centre
- Name and signature of testing body
- Model identification (type, theoretical movement capacity, N° of batch)
- Description of the test equipment and arrangement
- Date of the preparation of specimens, the date of test and the mean test temperature
- Dimensions and characteristics of test specimens
- Material characteristics (e.g. concrete quality of the support structure, prefabricated parts)
- Expression of monitored phenomena according to B.7

ANNEX C – ASSESSMENT OF RESISTANCE TO FATIGUE OF THE PRODUCT REPRESENTED BY FULL-SCALE COMPONENT TESTING

C.1 - SCOPE

This annex describes the method for assessing the resistance to fatigue of the product represented by components of cantilever expansion joints by testing.

C.2 - PRINCIPLES

The principle of this test procedure is to apply loads, derived from calculation for the fatigue loads and to investigate the different fatigue life categories in relation to the working life categories. The test results will be used to assess the requirements according to Clause 2.2.2.

At least two specimens covering the relevant type according to Clause 2.2.2 shall be tested.

C.3 - SAMPLES AND PREPARATION OF TEST SPECIMENS

The test specimens shall correspond to the relevant part of the design including all features.

The preparation of the test specimen is under the responsibility of the manufacturer.

C.4 - LOAD ARRANGEMENT

C.4.1 TEST LOADS AND NUMBER OF CYCLES

The concerned test load shall be derived from the loads on the expansion joint, taking into account the concerned contact pressure, the wheel print and the number of cycles, given in Annex D, in conjunction with an opening position of 60 % of the maximum opening position.

C.4.2 APPLICATION OF TEST LOAD

The application of loads shall take into account the representative introduction of the loads into the component and into the substructure.

C.5 - TESTING ARRANGEMENT

The test conditions shall represent an appropriate modelling of the built-in conditions.

If there is a range with the same type, then take one test at each border of the range and one test in the middle of the range.

C.6 - EXECUTION OF THE TEST

Execution of traffic load test:

The test shall be carried out at ambient temperature.

The principles, given in Annex D in this EAD for the full-scale test, apply.

If relevant, load reversals (tension/compression) shall be considered.

C.7 - EXPRESSION OF THE RESULTS

Traffic load test

The following shall be monitored and recorded:

- Applied loads (kN) and cycles, corresponding deformations
- Cracks (supported by photographs)
- Loosening, breaking

C.8 - TEST REPORT

The test report shall refer to the present annex and shall include at least the following:

- Name of the manufacturer and production centre
- Name and signature of testing body
- Model identification (type, theoretical movement capacity, N° of batch)
- Description of the test equipment
- Date of the preparation of specimens, the date of test and the mean test temperature
- Dimensions and characteristics of test specimens
- Expression of monitored phenomena according to Clause C.7

ANNEX D – ASSESSMENT OF RESISTANCE TO FATIGUE BY FULL-SCALE KIT TESTING

D.1 - SCOPE

This annex describes the method for assessing the resistance to fatigue of cantilever expansion joints by full-scale testing.

D.2 - PRINCIPLES

The principle of this test procedure is to apply traffic loads, idealised by contact pressures on a defined area and load cycles.

One specimen of each type has to be tested.

If there is a range with the same type, then take one test at each border of the range and one test in the middle of the range.

D.3 - SAMPLES AND PREPARATION OF TEST SPECIMENS

The test specimens shall correspond to the complete design including all features. The length of the test specimen (perpendicular to the movement direction) shall be at least 400 mm enlarged with an addition of the load dispersal effect (see Figure D.1), representative for the transfer of the reaction forces.

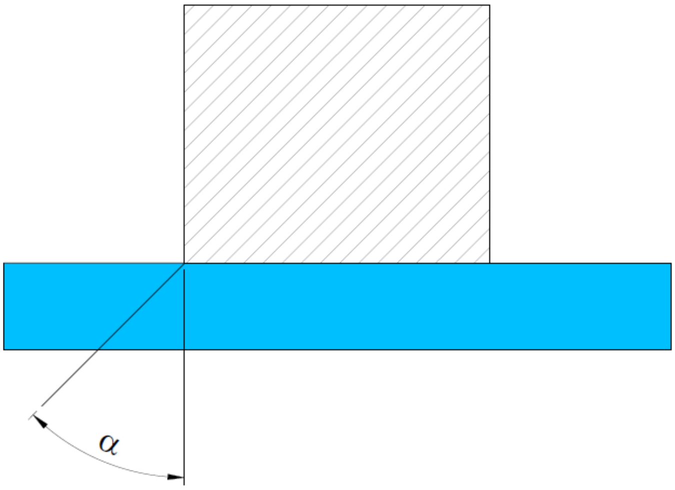


Figure D.1: Load dispersal effect (the angle α is depending on the material and combination of materials)

The preparation of the test specimen is under the responsibility of the manufacturer.

D.4 - LOAD AND MOVEMENT ARRANGEMENTS

D.4.1 TRAFFIC LOADS AND NUMBER OF CYCLES

The test loads are to be derived from $FLM1_{EJ}$ and/or $FLM2_{EJ}$ for a contact pressure of 0,8 N/mm² and 1,0 N/mm² respectively, in accordance with EAD 120109-00-0107, Annex D, Clause D.2. According to this, the conditions in the following Table D.1 apply. Reference for these conditions is given to Annex F.

Table D.1: Load cycles for assessment of different fatigue lives in relation to the working life categories

Cantilever Expansion Joints (including anchorage system)		Number of cycles				
		$FLM2_{EJ}$				$FLM1_{EJ}$
Test description		10 years	15 years	25 years	50 years	Unlimited
Contact pressure: 0,8 N/mm²	1st stage: vertical and horizontal loads simultaneously applied	1,7 x 10^6	2,5 x 10^6	4,2 x 10^6	7,4 x 10^6 ($FLM1_{EJ}$ applies)	7,4 x 10^6
	2nd stage: vertical loads only applied	1,1 x 10^6	1,7 x 10^6	2,9 x 10^6	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	2,8 x 10^6	4,2 x 10^6	7,1 x 10^6	7,4 x 10^6 ($FLM1_{EJ}$ applies)	7,4 x 10^6
Contact pressure: 1,0 N/mm² (alternatively to 0,8 N/mm²)	1st stage: vertical and horizontal loads simultaneously applied	0,87 x 10^6	1,3 x 10^6	2,2 x 10^6	3,8 x 10^6 ($FLM1_{EJ}$ applies)	3,8 x 10^6
	2nd stage: vertical loads only applied	0,57 x 10^6	0,87 x 10^6	1,5 x 10^6	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	1,44 x 10^6	2,17 x 10^6	3,7 x 10^6	3,8 x 10^6 ($FLM1_{EJ}$ applies)	3,8 x 10^6

Note 1: For simplification it is possible to replace n_v by n_{v+h}.

Note 2: For idealisation of axle load histogram to maximum axle loads with equivalent numbers of cycles m = 3 is used. Use of m = 3 is related to the situation that the load transferring components are made of steel.

Note 3: If horizontal loads can be neglected (see also Clause 2.2.1), the total numbers of vertical load cycles become: 2,8 (10 years category), 4,2 (15 years category) and 7,1 million (25 years category) for contact pressure = 0,8 N/mm². For 50 years category the total number of cycles related to $FLM1_{EJ}$ applies.

For contact pressure = 1,0 N/mm² a similar simplification applies.

Minimum vertical test load per wheel = A_{min} x 0,8 = 300 x 250 x 0,8 = 60 x 10^3 N = 60 kN.

Corresponding horizontal test load per wheel = (0,2/1,3) x 60 = 9,2 kN.

The partial factor $\gamma_{F,f}$ = 1,0.

D.4.2 POSITION OF LOAD TO BE APPLIED

The load shall be applied in the most adverse position. The complete surface of the intersecting cantilevers may be considered for the fatigue load transfer, provided that at SLS conditions according to Clause 2.2.1 the level differences do not exceed 5 mm. If this condition is not fulfilled the level difference shall not exceed 5 mm under fatigue loads in order to take into account the complete surface of the intersecting cantilevers (see also Clause 2.2.2). If both conditions are not fulfilled intersecting cantilevers cannot be taken into account.

D.5 - TESTING CONDITIONS

The test load shall be derived from Clause D.4 and distributed according to EAD 120109-00-0107, Annex D, Clause D.2.1 and Clause 2.2.1 of this EAD. It shall be applied with an angle according to the vertical and horizontal load ratio given in EAD 120109-00-0107, Annex D, Clause D.2 in the direction of the expansion joint gap (see EAD 120109-00-0107, Annex D, Clause D.2.3.3).

The test is carried out under the following conditions:

- Test temperature: The ambient temperature during the test shall be between +5 °C and +30 °C. These conditions cover all operating temperatures, taking in account the conditions, given in Clause 1.2.1.1.
- Number of load cycles: The number of load cycles is determined according to the specified categories of working life (see Clause 1.2.2 and D.4).

- Positioning of the sample: The test shall be carried out at 60 % of the maximum opening position. The relative positioning of the travelling loads on the sample shall be the most unfavourable loading condition.
- Frequency: The frequency shall be equal to or greater than 0,5 Hz.

D.6 - TESTING EQUIPMENT

The support of the test specimen shall simulate realistic support conditions, including anchorage etc.

The testing arrangement shall allow the application of the forces within a tolerance of ±5 % and shall include a suitable device for counting the number of cycles.

The actuators shall be calibrated and the actuating system shall not cause inaccuracies in the measurements.

The test arrangement shall show no resonance effects. A dynamic analysis of the test arrangement shall show that no resonance effects are to be expected.

Devices for counting the number of cycles shall be adapted to the maximum frequency of the test while allowing the recording of the data of the test.

The measuring tolerances on load shall be ±1 kN.

D.7 - EXECUTION OF THE TEST

The test shall be run at ambient temperature (see Clause D.5).

The test shall be carried out at 60 % of the maximum opening position with related level difference(s) for unloaded conditions with the number of cycles according to Clause D.4.1. 60 % is related to the complete range of movement (maximum movement capacity, see also EAD 120109-00-0107, Annex D, Clause D.2.4.2.4).

One cycle includes loading and unloading of the specimen. This includes that at the end of a stroke the wheel has completely lost contact with the joint.

In the case of an over-rolling test each loaded stroke is counted as one cycle. The vertical and horizontal loads shall be applied simultaneously during each cycle.

During the test, at the stages corresponding to 10 000, 100 000 and every 500 000 load cycles and at the end of test the joint shall be visually inspected and possible damages (e.g. cracking of the rubber, defect of fixing of the rubber profile in its groove, plastic deformation, failure of welding) shall be recorded.

D.8 - EXPRESSION OF THE RESULTS

The following shall be monitored and recorded:

- Applied loads (kN) and cycles, corresponding deformations
- Cracks (supported by photographs)
- Any other changes (e.g. with respect to the butt joint)
- Loosening, breaking

D.9 - TEST REPORT

The test report shall refer to the present annex and shall include at least the following:

- Name of the manufacturer and production centre
- Name and signature of testing body
- Model identification (type, theoretical movement capacity, N° of batch)
- Description of the test equipment; the consistency of the assessment of how the criteria and guidance of this annex are respected
- Date of the preparation of specimens, the date of test and the mean test temperature
- Dimensions and characteristics of test specimens
- Expression of monitored phenomena according to Clause D.7

- Test conditions and operational details not detailed in this document as well as the possible incidents likely to have affected the results

ANNEX E – PRINCIPLES FOR THE ASSESSMENT METHOD GIVEN IN ANNEX B

E.1 - SLS/ULS 1: 60 % OF THE MAXIMUM OPENING IN COMBINATION WITH 100 % SLS/ULS LOAD LEVEL

The 60 % opening position is related to the conditions, described with ψ_{Od} = 0,6 for C_{ULS} = 1 according to EAD 120109-00-0107, Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

The 60 % of the maximum opening position (maximum movement capacity) is related to the complete range of movement.

The 100 % ULS load level is related to the conditions, described with ψ_{OT} = 1,0 for C_{ULS} = 1 according to EAD 120109-00-0107, Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

Note 1: The design situation for C_{SLS} is considered to be analogous to C_{ULS} (see also EAD 120109-00-0107, Annex D, Clause D.2.4.3).

Background for derivation of loads for ULS (EAD 120109-00-0107, Annex D, Clause D.2) assessment (see Clause 2.2.1):

The vertical load is 1,35 x 150 kN acting on two wheel prints of 300 mm x 250 mm (contact pressure of 1,35 N/mm²). Where necessary, the load and the wheel print may be reduced, keeping the concerned contact pressure. The horizontal load in the traffic direction (longitudinal) is 0,4 of the vertical test load and the horizontal load perpendicular to the traffic direction (transverse direction) is 0,2 of the vertical test load. If the test specimen is subjected to a combination of vertical and horizontal loads, the combination factors ψ as given in EAD 120109-00-0107, Annex D, Table D.6, apply.

Explanation: The joint shall at least fulfil the mechanical strength at the design load level (= 1,35 – according to EN 1990, Annex A2, Table A2.4 (B) Design values of actions – times the characteristic loads given in EAD 120109-00-0107, Annex D, Table D.3). However there is an uncertainty in the quality of the specimen.

Note 2: Background for derivation of loads for SLS (EAD 120109-00-0107, Annex D, Clause D.2) assessment: (see Clause 2.2.1):

The load shall be derived from a vertical test load being 150 kN acting on two wheel prints of 300 mm x 250 mm (contact pressure of 1,00 N/mm²). Where necessary, the considered load and the considered wheel print may be reduced, keeping the theoretical contact pressure. The considered theoretical horizontal load in traffic direction (longitudinal) is 0,4 (according to EAD 120109-00-0107, Annex D, Clause D.2.3.2.1) of the vertical load and the horizontal load perpendicular to the traffic direction (transverse direction) is 0,2 (according to EAD 120109-00-0107, Annex D, Clause D.2.3.2.2) of the vertical load. If the test specimen is subjected to a combination effect of vertical and horizontal loads, the combination factors ψ as given in EAD 120109-00-0107, Annex D, Table D.6, apply.

E.2 - SLS/ULS 2: 100 % OF THE MAXIMUM OPENING IN COMBINATION WITH 70 % SLS/ULS LOAD LEVEL

The 100 % opening position is related to the conditions, described with ψ_{Od} = 1,0 for C_{ULS} = 2 according to EAD 120109-00-0107, Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

The 70 % ULS load level is related to the conditions, described with ψ_{OT} = 0,7 for C_{ULS} = 2 according to EAD 120109-00-0107, Annex D, Clause D.2.4.2.1 and D.2.4.3.1.

Note: The situation for C_{SLS} is considered to be analogous to C_{ULS} (see also EAD 120109-00-0107, Annex D, Clause D.2.4.3).

E.3 - SITUATION ACCORDING TO EAD 120109-00-0107, ANNEX D, CLAUSE D.2.4.3.2 (FREQUENT COMBINATION)

Depending on the design of the cantilever expansion joint, frequent combination may be not considered in the assessment.

E.4 - ALTERNATIVE ASSESSMENT PROCEDURE

This assessment procedure may apply in agreement between manufacturer and TAB.

(Instead of following testing procedure 1 + procedure 2 according to Annex B with reference to opening positions given in Annex E, Clauses E.1 and E.2): opening position: 100 % in combination with 100 % SLS load level (ψ_{Od} and ψ_{OT} = 1,0)

According to EAD 120109-00-0107, Annex D, Clause D.2.4.3.1, SLS1 and SLS2 can be covered by an envelope approach with the condition ψ_{Od} and ψ_{OT} = 1,0.

For ULS due to the specific situation of level differences at intersecting cantilevers no distinction between ULS1 and ULS2 has to be made. For ULS 100 % load level applies.

ANNEX F – EXAMINATION OF REQUESTED LOAD CYCLES AND REQUESTED LOADS FOR ASSESSMENT OF FATIGUE RESISTANCE FOR A FATIGUE LIFE OF 10, 15, 25 AND 50 YEARS AND UNLIMITED FATIGUE LIFE

F.1 - FOREWORD

The objective of this annex is to give sufficient background information on the used loads and load cycles used in Annex D in conjunction with EAD 120109-00-0107, Annex D, Clause D.2 and EN 1991-2.

Sources: EAD 120109-00-0107, Annex D, Clause D.2.3.3.3 $FLM2_{EJ}$, Table D.5 + N_{obs} according to EN 1991-2, Table 4.5.

Precondition: If for cantilever expansion joints for the kit (according to Clause 2.2.2) or parts of them (anchorage) unlimited fatigue life is of relevance $FLM1_{EJ}$ according to EAD 120109-00-0107, Annex D, Clause D.2 applies. If limited fatigue life is of relevance, $FLM2_{EJ}$ according to EAD 120109-00-0107, Annex D, Clause D.2 applies.

This Annex is based on a slope of maximum 4 %.

Method: According to the damage equivalent method used for steel and rubber (equivalent with highest loads).

Note: Fatigue life is the contribution to the working life governed by the fatigue endurance.

F.2 - EQUIVALENT NUMBER OF AXLE RATES FOR CANTILEVER EXPANSION JOINTS AND ANCHORAGE SYSTEMS

Table F.1: Idealisation of axle load histogram to maximum axle loads with equivalent numbers of cycles

$Q_{1k,fat}$ Vertical axle load kN	$Q_{1lk,fat}$ Horizontal axle load kN in traffic direction	Axle number rate	Equivalent number of axle rates for vertical loads	Equivalent number of axle rates for horizontal loads	Axle type
100	-	1,1	0,16	-	A
120	-	1,25	0,31	-	C
150	20	0,20	0,10	0,07	B
170	24	0,45	0,32	0,28	B
190	28	0,45	0,45	0,45	B
190	28	Σn_{equ}	1,34	0,80	

Background:

- Horizontal loads are related to traction forces only
- $0,16 = 1,1 \times (100/190)^3$
- $0,07 = 0,20 \times (20/28)^3$
- Exp3 – see Palmgren-Miner hypothesis about damage accumulation (Fictitious: m = 3; related to the situation that most of relevant components are made of steel)

For other materials the appropriate fatigue classifications and S-N-lines shall be derived from standards or testing.

$Q_{1k,fat}$ according to EAD 120109-00-0107, Annex D, Table D.5, including $\Delta\varphi_{fat} = 1,3$

$Q_{1lk,fat}$, including $\Delta\varphi_{fat} = 1,0$

Axle number rate according to EAD 120109-00-0107, Annex D, Table D.5

Background: 500 000 lorries per year >> see N_{obs}:

- 10 = 10 years working life according to category 1 (10 years)
- 15 = 15 years working life according to category 2 (15 years)
- 25 = 25 years working life according to category 3 (25 years)

- 50 = 50 years working life according to category 4 (50 years)

F.3 - CONCLUSION FOR REQUESTED LOAD CYCLES FOR AXLE LOADS ON CANTILEVER EXPANSION JOINTS

Fatigue behaviour is tested as a summation of two load categories:

- Vertical loads
- Vertical loads combined with horizontal loads in the traffic direction

1. Load cycle derived from vertical axle load 190 kN (see Table F.1, line 5):

$$\Sigma n = (1,34 – 0,80) \times 500\,000 \times 10 = 0,54 \times 500\,000 \times 10 = 2,7 \times 10^6$$

2. Load cycle derived from vertical axle load (190 kN) in combination with horizontal axle load 28 kN (see Table F.1, line 5):

$$\Sigma n = 0,80 \times 500\,000 \times 10 = 4 \times 10^6$$

Note 1: Resulting load: $(190^2 + 28^2)^{0.5}$ = 192 kN. Inclination of load application: 8,4°.

Note 2: Table F.1 shows that only the 100 kN up to 150 kN vertical axle loads represent a very small volume of the total axle load cycles. Therefore the Σn for combination of vertical and horizontal loads in sub clause 2 has a relative high value, compared to Σn in sub clause 1 for F_v (see also F_{v+h} and F_v in Tables F.2 and F.3).

F.4 - TEST LOAD (F) FOR CANTILEVER EXPANSION JOINTS, BASED ON $FLM2_{EJ}$

1. According to the EN 1991-2 the maximum vertical axle load (190 kN) for $FLM2_{EJ}$ is related to an axle with two dual tyres.

2. The wheel print area of 300 mm x 250 mm according to EAD 120109-00-0107, Annex D, Clause D.2 substitutes a dual tyre print with a related load of 190/4 = 47,5 kN.

3. The related theoretical contact pressure = 47500/(300 x 250) = 0,63 N/mm².

4. The contact pressure for wheels of lorries in practice = 0,8 N/mm² (8 bar internal tyre pressure).

Consequence for the test load to be used:

Due to the geometry and the load path of cantilever expansion joints and the need to consider realistic strain intervals in these structures, for cantilever expansion joints the contact pressure is considered as the most relevant aspect for fatigue behaviour. In order to assess this, the contact pressure of 0,8 N/mm² needs to be taken into account. This contact pressure is considered to act on a fictitious wheel print of at least 300 mm x 250 mm. The effect of the voids is disregarded.

Consequently, the requested vertical test load F_{Tv} has to be calculated, using an average contact pressure (0,8 N/mm²) and a fictitious contact area not smaller than 300 mm x 250 mm.

5. In order to achieve a reduced number of cycles for testing it is allowed to increase the contact pressure to a maximum of 1,0 N/mm². In such cases, a reduction of load cycles can be calculated as follows: $((0,8/p_{requested})^3)$ x load cycles.

Example for $p_{requested}$ = 1,0: $(0,8/1,0)^3$ = 0,5 x load cycles.

The horizontal test load F_{Th} is calculated as follows: $F_{Th} = (28/190) \times F_{Tv}$

F.5 - TEST LOAD (F) FOR CANTILEVER EXPANSION JOINTS, BASED ON $FLM1_{EJ}$

1. According to EAD 120109-00-0107, Annex D, Clause D.2.3.3.2, the maximum vertical axle load is 273 kN for $FLM1_{EJ}$. This is related to a theoretical wheel print of 300 mm x 250 mm.

2. According to EAD 120109-00-0107, Annex D, Clause D.2.3.3.2, the maximum horizontal axle load is 42 kN for $FLM1_{EJ}$.

3. The wheel print area of 300 mm x 250 mm according to EAD 120109-00-0107, Annex D, Clause D.2 is assumed to represent a dual tyre print with a related load of 273/4 = 68,3 kN. According to this the theoretical vertical test load per wheel = 68 kN.

4. The related theoretical contact pressure = 68300/(300 x 250) = 0,91 N/mm². In principle, this covers the contact pressure in practice. If for $FLM1_{EJ}$ the contact pressure is reduced from 0,91 N/mm² to 0,8 N/mm², the associated number of cycles is $(0{,}91/0{,}8)^3$ x 5 000 000 = 7,4 x 10^6.

5. In order to achieve a reduced number of cycles for testing it is allowed to increase the contact pressure. Whereas increasing the contact pressure to 1,0 N/mm² is considered appropriate in general. In such cases, a reduction of load cycles can be calculated as follows: $((0{,}91/p_{requested})^3)$ x load cycles.

Example for $p_{requested}$ = 1,0: $(0{,}91/1{,}0)^3$ = 0,75 x load cycles.

Consequence for the test load to be used: The requested vertical test load F_{Tv} has to be calculated, using the internal tyre pressure (0,91 N/mm²) and a contact area not smaller than 300 mm x 250 mm.

The horizontal test load F_{Th} is calculated according to EAD 120109-00-0107, Annex D, Clause D.2.3.3.2, as follows:

$F_{Th} = (0{,}2/1{,}3) \times F_{Tv}$.

F.6 - SUMMARIZING TABLE OF CALCULATED LOAD CYCLES FOR DIFFERENT FATIGUE LIVES

For limited fatigue life the accumulated number of cycles is stated in relation to a working life in years according to EAD 120109-00-0107, Annex D, Clause D.2.

For unlimited fatigue life the contact pressure and number of cycles is stated in relation to EAD 120109-00-0107, Annex D, Clause D.2 and EN 1991-2.

Table F.2: Calculated load cycles

Item		**$FLM2_{EJ}$**				**$FLM1_{EJ}$**
		10 years	**15 years**	**25 years**	**50 years**	**Unlimited**
Cantilever Expansion Joints, including anchorage system (Contact pressure: **0,8** N/mm²)	n_{v+h}	1,7 x 10^6	2,5 x 10^6	4,2 x 10^6	8,4 x 10^6	**7,4 x 10^6**
	n_v	1,1 x 10^6	1,7 x 10^6	2,9 x 10^6	5,8 x 10^6	
Cantilever Expansion Joints, including anchorage system (Contact pressure: **0,91** N/mm²)	n_{v+h}			-	-	**5 x 10^6**
Remarks					*Number of cycles exceeds those for $FLM1_{EJ}$ (unlimited fatigue life).>> $FLM1_{EJ}$ applies.*	

Boundary assumptions for the derivation of test loads and test cycles in conjunction with the Eurocode traffic load models:

1. No cut-off limits used for the determination of equivalent numbers of cycles and increased loads,

2. For steel m = 3,

3. 1,30 according to dynamic amplification factor ($\Delta\varphi_{fat}$), included in the loads according to EAD 120109-00-0107, Annex D, Clause D.2,

4. n = 5 x 10^6 according to EN 1991 for constant amplitude fatigue limit $\Delta\sigma_D$,

5. V = Vertical axle load, H = Horizontal axle load.

Remark: The 2 x 10^6 load cycles are normally used as a reference level for classification of fatigue for non-elastomeric parts (Wöhler).

Comment on comparison between limited fatigue life 50 years and unlimited fatigue life according to EN 1991: Due to the simplification of the S-N-line in conjunction with the axle load histogram the limited fatigue life testing conditions approach the conditions for unlimited fatigue life for fatigue design lives of approximately 20 years for cantilever expansion joints.

F.7 - NUMBER OF LOAD CYCLES FOR DIFFERENT FATIGUE LIVES

Table F.3: Load cycles for assessment of different fatigue lives in relation to the working life categories

Cantilever Expansion Joints (including anchorage system)		**Number of cycles**				
Test description		**$FLM2_{EJ}$**				**$FLM1_{EJ}$**
		10 years	**15 years**	**25 years**	**50 years**	**Unlimited**
Contact pressure: 0,8 N/mm²	1st stage: vertical and horizontal loads simultaneously applied	$1,7 \times 10^6$	$2,5 \times 10^6$	$4,2 \times 10^6$	$FLM1_{EJ}$ applies	$7,4 \times 10^6$
	2nd stage: vertical loads only applied	$1,1 \times 10^6$	$1,7 \times 10^6$	$2,9 \times 10^6$	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	$2,8 \times 10^6$	$4,2 \times 10^6$	$7,1 \times 10^6$	$FLM1_{EJ}$ applies	$7,4 \times 10^6$
Contact pressure: 1,0 N/mm² (alternatively to 0,8 N/mm²)	1st stage: vertical and horizontal loads simultaneously applied	$0,87 \times 10^6$	$1,3 \times 10^6$	$2,2 \times 10^6$	$FLM1_{EJ}$ applies	3.8×10^6
	2nd stage: vertical loads only applied	$0,57 \times 10^6$	$0,87 \times 10^6$	$1,5 \times 10^6$	--	--
	Envelope approach: vertical and horizontal loads simultaneously applied	$1,44 \times 10^6$	$2,17 \times 10^6$	$3,7 \times 10^6$	($FLM1_{EJ}$ applies)	$3,8 \times 10^6$

Note 1: For idealisation of the axle load histogram to maximum axle loads with equivalent numbers of cycles m = 3 is used. The use of m = 3 is related to the situation that the load transferring components are made of steel.

Note 2: If horizontal loads can be neglected (see also Clause 2.2.1), the total numbers of vertical load cycles become: $2,8 \times 10^6$ (10 years category), $4,2 \times 10^6$ (15 years category) and $7,1 \times 10^6$ (25 years category) for contact pressure = 0,8 N/mm². For 50 years category the total number of cycles related to $FLM1_{EJ}$ applies.

For contact pressure = 1,0 N/mm² a similar simplification applies.

Derivation of test loads from contact pressure:

The load application shall be executed by means of a contact area which simulates the geometry and stiffness of the wheel.

In case of pulsating test: elastomeric pad: ≥ 300 mm x 250 mm:

- Minimum vertical test load per wheel = $A_{min} \times 0,8 = 300 \times 250 \times 0,8 = 60 \times 10^3$ N = 60 kN,

- Corresponding horizontal test load per wheel = (0,2/1,3) x 56 = 8,4 kN,

- The partial factor $\gamma_{F,f} = 1,0$.

ANNEX G – DYNAMIC ASSESSMENT AND FIELD TESTING

G.1 Introduction

A expansion joint is a kit, assembled from components. In addition field-testing allows the determination of the dynamic behaviour of the kit or single components of joints in accordance with the relevant parts.

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

G.2 Objective

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

G.3 Principles

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

One test specimen, subjected to two passing test lorries with different speeds, is sufficient.

The results of the test and analyses apply for joints of the same type, but with other dimensions, provided the calculated vertical, horizontal and rotation natural frequencies do not fall below 90% of those of the originally tested and analysed expansion joint.

Dynamic amplifications and upswing shall be directly calculated from strains.

G.4 Scope and range of application

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

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

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

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

The test pieces shall be full-scale joints. The type, which is the most susceptible against dynamic influences, shall be tested (e.g. longest cantilever, worst relations of geometries).

The evenness of the joint shall meet the manufacturer’s design specifications. The evenness of the adjacent pavement shall be of medium quality (See EN 1991-2, 4.2.1, Note 3). The alignment shall be smooth, without discontinuities.

One specimen of each type has to be tested.

The preparation of the test specimen is under the responsibility of the manufacturer.

G.6 Testing arrangement and conditions

G.6.1 Location and conditions

The joint is located in a road and installed similarly to real “built-in” situations. The opening positions of the joint shall be at 60 % of movement capacity (middle position +/- 5 mm. The tests are carried out at ambient temperatures (between +5 °C and +35 °C).

G.6.2 Instrumentation

The instrumentation of the expansion joint shall consist of a combination of accelerometers, strain gauges and displacement sensors on e.g. finger plates, bolts (see Figure G.1).

For Cantilever Expansion Joint:

- The minimum required opening has to be defined
- Strain gauges for measuring bending stress below the cantilever
- Strain gauges for measuring shear stress at both sides
- Instrumented bolts to measure forces in bolts

The instrumentation shall allow a clear analysis of vertical bending, horizontal bending, torsion and/or tilting. The sampling frequency of the instrumentation shall allow a proper analysis of the dynamic behaviour. The accuracy of measured variable shall be at least 5% of the maximum measured value.

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

A minimum sampling frequency of 10 to 15 times the highest relevant natural frequency (e.g. 1 500 Hz) is recommended for the data acquisition. In addition a minimum sampling frequency shall correspond to 10 times the inverse of the loading time (equal to the sum of length of the wheel print and length of a single contact surface, divided by the vehicle speed).

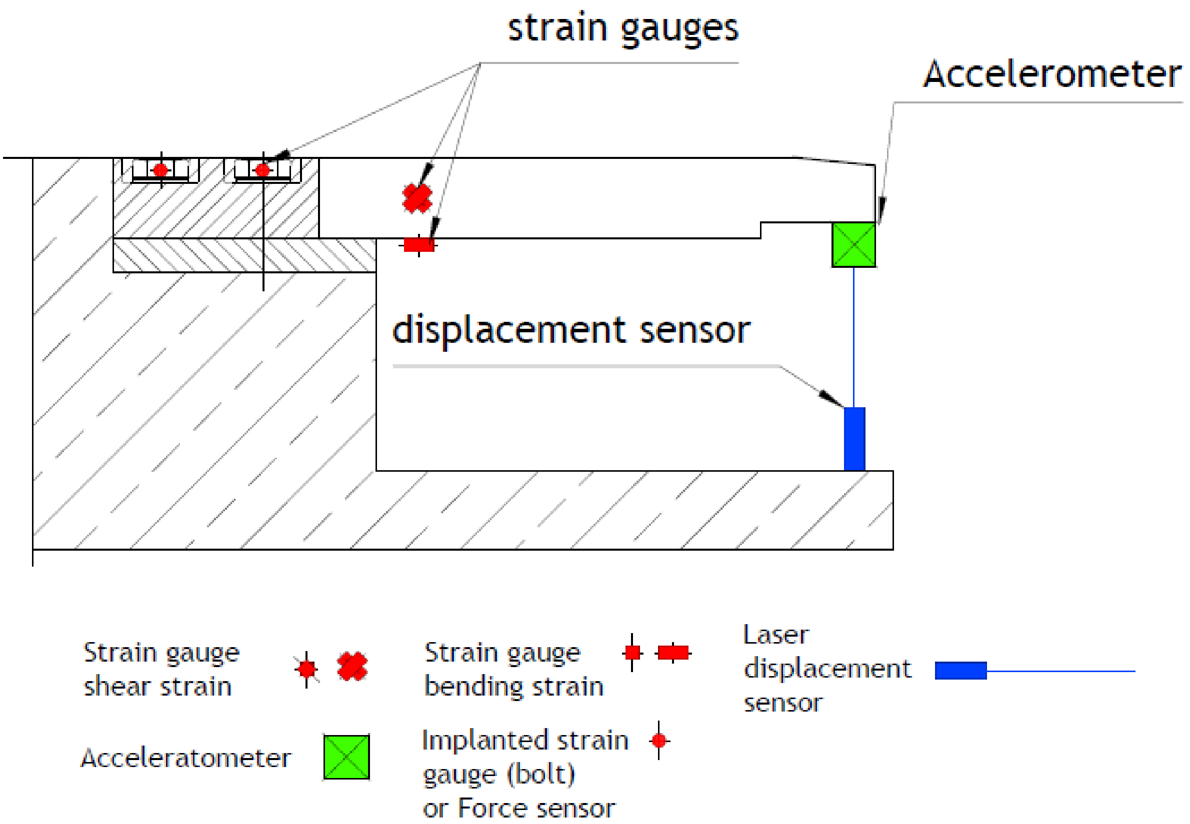


Figure G.1: Typical arrangements of measuring devices

G.6.3 Positioning of measuring devices

The position and the type of measuring devices shall be reported in a plan, which also shows the over rolling positions of the wheels (see Figure G.2). The plan shall also indicate the channel numbers etc. in order to allow full traceability of the records during interpretation and evaluation.

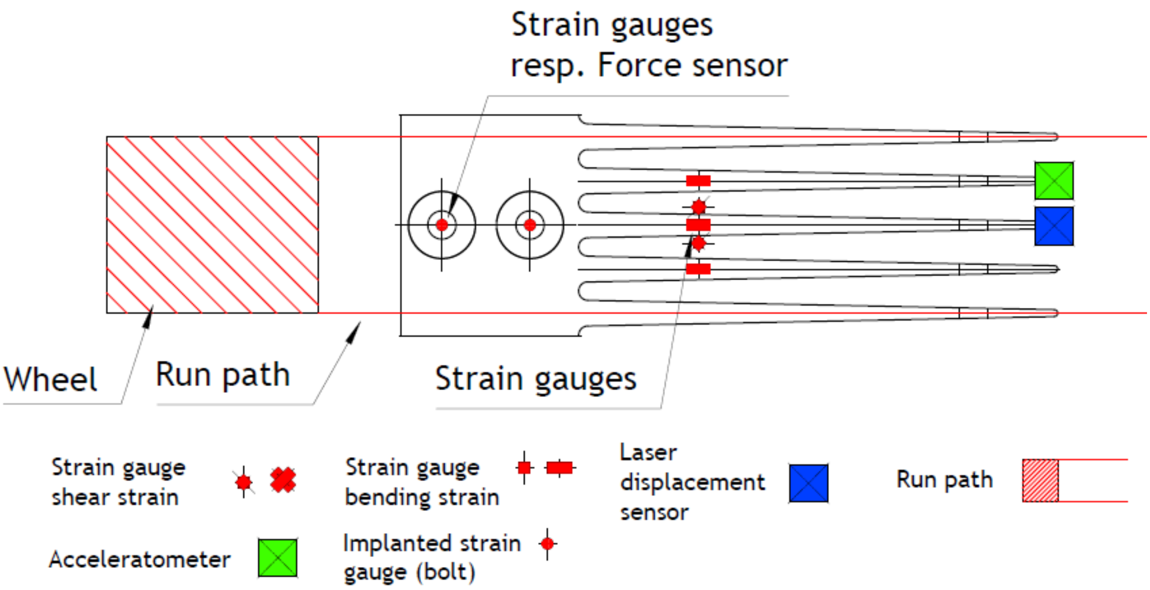


Figure G.2: Transverse positions for over rolling

G.7 Load arrangements and execution of over rolling tests

G.7.1 Excitation

Prior to the over rolling test, the natural frequencies and natural vectors of the joint shall be determined.

G.7.2 Over-rolling test

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

Subsequently the over-rolling tests are carried out:

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

Table G.7.2: Lorry speeds and positions

Sequence	Speed (km/h)
1	≤ 5
2	50*
3	70*
4	90*

* Determination of test speed by axle spacing and natural frequency

40 km/h < $v=(a_i * f_1 *3,6) / n_{v2}$ <= 60 km/h
60 km/h < $v=(a_i * f_1 *3,6) / n_{v3}$ <= 80 km/h
80 km/h < $v=(a_i * f_1 *3,6) / n_{v4}$ <= 100 km/h
$v = l_{wheel\ print} \times f_1$ <= 120 km/h

Where a_i [m] minimum axle spacing of the test lorry
f_1 [Hz] first natural frequency (in vertical and/or horizontal direction)
n_{v2}, n_{v3}, n_{v4} integer
$l_{wheel\ print}$ length of the wheel print
v Lorry speed [km/h]

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

For each speed and each transverse position the number of over-rolling with the vehicle is at least 3.

The transverse position of the wheel shall be the same as a measuring device.

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

The (transverse) position of the over rolling wheels shall be reported.

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

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

The following lorry types are recommended:

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

G.8 Measurements and analyses

The following aspects shall be measured for further interpretation.

G.8.1 Lorry

1. Wheel print geometry (static) (5% accuracy),
2. Tyre pressures (5% accuracy),
3. Travelling speed of the lorry above the joint (5% accuracy),
4. Travelling position in transverse direction (10% accuracy).

G.8.2 Expansion joint

The following shall be measured:

1. Width of finger plates,
2. Gap width (5% accuracy),
3. Strains (with gauge) (5% accuracy),
4. Accelerations (5% accuracy),
5. Distance (with laser) (5% accuracy).

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

G.8.3 Over-rolling tests

G.8.3.1 Effects in the vertical plane

G.8.3.1.1 Initial dynamic impact factor

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

Analysis:

- Vertical support moment: M_{sv} [kNm],
- Vertical moment interval static: M_{Sv0} [kNm],
- Vertical moment interval at sequence "i" with ($v \neq 0$): M_{Svi} [kNm],
- Dynamic impact factor: $\Delta\varphi_{fat} = M_{Svi}/M_{Sv0} \geq 1.0$ [-]. The dynamic impact factor shall be calculated with the 95%-fractile of the test results.

G.8.3.1.2 Upswing

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

The vertical Upswing ratio $U_v = M_{Svu}/M_{Sv}$ [-]

The vertical upswing ratio shall be calculated with the 95%-fractile of the test results.

G.8.3.1.3 Combined dynamic vertical effect

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

$$E_{dv,dyn} = E_{dv0} \times \Delta\varphi_{fat} \times (1 + U_v) \text{ [kN]}$$

G.8.3.2 Effects in the horizontal plane

The section moments shall be derived from the section moments at the strain gauge locations, taking into account the transversely distributed load introduced by the wheel print. The moments shall be summed for the determination of the transfer factor. The transfer factor "tr" for the considered velocity is the measured horizontal moment interval for sequence "i" M_{Sh}, divided by the vertical M_{Sv0}.

Analysis:

- Vertical support moment for a static load (v=0km/h): M_{sv0} [kNm],
- Vertical moment interval for a static load (v=0km/h): $M_{Sv0} = M_{sv0} + M_{mv0}$ [kNm],
- Horizontal moment interval for a moving load (v_i > 0km/h): $M_{Shi} = M_{shi} + M_{mhi}$ [kNm],
- Transfer factor V/H incl. $\Delta\varphi_{fat}$: $tr = M_{Shi}/M_{Sv0} \geq 1.0$ [-]. The transfer factor shall be calculated with the 95%-fractile of the test results.

G.8.3.3 Response ratio

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

The horizontal response ratio $U_h = M_{Shu}/M_{Sh}$ [-].

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

G.8.3.4 Combined dynamic vertical effect

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

$$E_{dh,dyn} = E_{dh0} \times \Delta\varphi_{fat} \times (1 + U_h) \text{ [kNm]}$$

G.9 Calculations

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

G.9.1 General

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

G.9.2 Calculation results

The natural frequencies and natural vectors shall be calculated. The results shall be compared with the measured natural frequencies and natural vectors that can be derived from the measurements.

For the assessment of the model the measured natural frequencies and mode shapes shall be compared with calculated ones. The strains and deflections due to walking speed over-rolling (according to sequence 1 in Table G.7.2) shall be compared with the simulated ones.

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

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

Note: No response calculations need to be carried out if: For upswing effects less than 2% of the quasi static load it can be considered no upswing, for dynamic amplification effects responses not larger than 1.05 the quasi static response can be considered no additional amplification.

G.9.3 Combination of effects

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

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

$$\Delta\sigma_{comb} = \Delta\sigma_v + \Delta\sigma_h \text{ [N/mm}^2$$

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

G.10 Test report

The test report shall comprise at least:

- Description of the joint, including the adjacent pavement over 30 m before and after the joint, slopes in traffic direction and perpendicular to the traffic direction;
- Drawing of the joint (dimensions, dimensions of components, material specifications etc.);
- Test lorry (configuration and static wheel loads, wheel print dimensions, inflation pressure of tyres, wheel and axle distances, position relative to the joint in transverse direction during over-rolling, over-rolling speed);

- Measuring devices (types, accuracy) and their locations (detailed sketches, related to the joint dimensions);
- Sampling frequency of measuring devices;
- Natural frequencies (vertical, horizontal, torsional);
- Vertical dynamic amplification factor $\Delta\varphi_{fat}$ for each crossing and 95% quantile;
- Transfer effects tr for each crossing;
- Upswing effect U_v, and horizontal response effect U_H for each crossing and 95% quantile;
- Date of test execution (environmental aspects: air temperature etc.).

G.11 Keys

v	[km/h]	lorry speed
a_i	[m]	minimum axle spacing of the test lorry
$l_{wheel\ print}$	[m]	length of the wheel print
f_1	[Hz]	first natural frequency in vertical and/or horizontal direction
d	[-]	damping ratio
n_{vi}	[-]	integer
$\Delta\varphi_{fat}$	[-]	vertical dynamic impact factor
M_{sv0}	[kNm]	Static vertical support moment (v = 0km/h)
M_{mv0}	[kNm]	Static vertical midspan moment (v = 0km/h)
M_{Sv0}	[kNm]	Static vertical moment interval (v = 0km/h)
M_{Svi}	[kNm]	Vertical moment interval at sequence i (v_i > 0km/h)
M_{svu}	[kNm]	vertical support moment after unloading (v_i > 0km/h)
M_{mvu}	[kNm]	vertical midspan moment after unloading (v_i > 0km/h)
M_{Svu}	[kNm]	vertical moment interval after unloading (v_i > 0km/h)
M_{Shi}	[kNm]	Horizontal moment interval (v_i > 0km/h)
M_{shi}	[kNm]	Horizontal support moment (v_i > 0km/h)
M_{mhi}	[kNm]	Horizontal midspan moment (v_i > 0km/h)
U_v	[-]	vertical upswing ratio
U_h	[-]	horizontal response ratio
$E_{d,dyn}$	[kN, kNm or N/mm^2]	vertical dynamic load (moment etc.) design interval
E_{dv0}	[kN, kNm or N/mm^2]	vertical static load (moment etc.) design interval (v = 0km/h)
$E_{dh,dyn}$	[kN, kNm or N/mm^2]	horizontal dynamic load (moment etc.) design interval
E_{dh0}	[kN, kNm or N/mm^2]	horizontal static load (moment etc.) design interval (v = 0km/h)
tr	[-]	transfer factor
$\Delta\sigma_{comb}$	[N/mm^2]	combined stress interval
$\Delta\sigma_v$	[N/mm^2]	vertical stress interval
$\Delta\sigma_h$	[N/mm^2]	horizontal stress interval
A_n	e.g. [µm/m]	response Amplitude "n"