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**Railway applications — Polymeric  
composite sleepers, bearers and  
transoms —**

**Part 2:  
Product testing**

*Applications ferroviaires — Traverses et supports en matériaux  
composites à matrice polymère —*

*Partie 2: Essais de produit*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 1, *Infrastructure*.

A list of all parts in the ISO 12856 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

This document is used as the technical basis for transactions between corresponding parties (purchaser – supplier).

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# Railway applications — Polymeric composite sleepers, bearers and transoms —

## Part 2: Product testing

### 1 Scope

This document specifies various test methods to ensure the performance of polymeric composite and reinforced polymeric composite sleepers, bearers and transoms for use in tracks. It is applicable to the sleepers, bearers and transoms to be installed in tracks with or without a ballast.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 12856-3:—<sup>1)</sup>, *Railway applications — Polymeric composite sleepers, bearers and transoms — Part 3: General requirements*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12856-3 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms listed in [Table 1](#) apply.

**Table 1 — Symbols**

| Symbol/<br>Abbreviated term | Description                                                                                                 | Unit              |
|-----------------------------|-------------------------------------------------------------------------------------------------------------|-------------------|
| $C_{\text{dyn}}$            | low frequency dynamic bedding modulus of polymeric composite sleeper or bearer measured with GBP            | N/mm <sup>3</sup> |
| $C_{\text{max}}$            | static bedding modulus of polymeric composite sleeper or bearer measured with geometric ballast plate (GBP) | N/mm <sup>3</sup> |
| $d_{\text{fat,lim}}$        | acceptable displacement of fatigue test as a maintenance policy                                             | mm                |
| $d_{0c}$                    | deformation of the sleeper in the compression test under $F_{R0}$                                           | mm                |

1) Under preparation. Stage at the time of publication: ISO/DIS 12856-3:2020.

Table 1 (continued)

| Symbol/<br>Abbreviated term | Description                                                                                                                                                                                   | Unit |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| $d_{1c}$                    | deformation of the sleeper in the compression test under $k_{1s} \times F_{r0}$                                                                                                               | mm   |
| $d_{1s,lim}$                | upper limit deformation related to the exceptional test load                                                                                                                                  | mm   |
| $d_{2c}$                    | deformation of the sleeper in the compression test under $k_{2s} \times F_{r0}$                                                                                                               | mm   |
| $d_{2s,lim}$                | upper limit deformation related to the accidental test load                                                                                                                                   | mm   |
| $\Delta k_c$                | variation of static and dynamic stiffness before and after the fatigue test at the centre section for positive bending moments                                                                | MN/m |
| $\Delta k_{c,n}$            | variation of static and dynamic stiffness before and after the fatigue test at the centre section for negative bending moments                                                                | MN/m |
| $\Delta k_r$                | the variation of static and dynamic stiffness before and after the fatigue test at the rail seat                                                                                              | MN/m |
| $e$                         | design distance between the centre line of the rail seat to the longitudinal girders of bridge                                                                                                | m    |
| $E_s$                       | thickness of ballast bed in a ballast box                                                                                                                                                     | mm   |
| $F_c$                       | positive test load at the centre section of the sleeper                                                                                                                                       | kN   |
| $F_{c0}$                    | positive initial test load at the centre section of the sleeper                                                                                                                               | kN   |
| $F_{c,n}$                   | negative test load at the centre section of the sleeper                                                                                                                                       | kN   |
| $F_{c,fat}$                 | positive fatigue test load at the centre section of the sleeper                                                                                                                               | kN   |
| $F_{c,fat,n}$               | negative fatigue test load at the centre section of the sleeper                                                                                                                               | kN   |
| $F_{c,perm,n}$              | constant load applied for permanent deformation test at the centre section for negative bending moments                                                                                       | kN   |
| FP                          | flat plate                                                                                                                                                                                    | n/a  |
| $F_r$                       | positive test load for the rail seat section                                                                                                                                                  | kN   |
| $F_{rB}$                    | maximum positive test load at the rail seat section which cannot be increased                                                                                                                 | kN   |
| $F_{r,fat}$                 | positive fatigue test load for the rail seat section                                                                                                                                          | kN   |
| $F_{r0}$                    | positive initial reference test load for the rail seat section                                                                                                                                | kN   |
| GBP                         | geometric ballast plate                                                                                                                                                                       | n/a  |
| $k_{c,dyn1}$                | low frequency dynamic stiffness on 10 cycles under applying a cyclic force of $F_{c,min}$ (= $0,1 \cdot F_{c0}$ ) to $F_{c,test1}$ (= $0,5 \cdot F_{c0}$ ) at $(5 \pm 1)$ Hz for 1 000 cycles | MN/m |
| $k_{c,dyn2}$                | Low frequency dynamic stiffness on 10 cycles under applying a cyclic force of $F_{c,min}$ (= $0,1 \cdot F_{c0}$ ) to $F_{c,test2}$ (= $F_{c0}$ ) at $(5 \pm 1)$ Hz for 1 000 cycles           | MN/m |
| $k_{c,n,stat1}$             | static stiffness of the fifth loading at the centre section for negative bending loads between $(0,1 \cdot F_{c0,n})$ and $(0,5 \cdot F_{c0,n})$                                              | MN/m |
| $k_{c,n,stat2}$             | static stiffness of the fifth loading at the centre section for negative bending loads between $(0,1 \cdot F_{c0,n})$ and $F_{c0,n}$                                                          | MN/m |
| $k_{dyn}$                   | low frequency dynamic stiffness of polymeric composite sleeper or bearer measured with GBP                                                                                                    | MN/m |
| $k_{max}$                   | static stiffness of polymeric composite sleeper or bearer measured with GBP                                                                                                                   | MN/m |
| $k_{r,dyn1}$                | low frequency dynamic stiffness on 10 cycles under applying a cyclic force of $F_{r,min}$ (= $0,1 \cdot F_{r0}$ ) to $F_{r,test1}$ (= $0,5 \cdot F_{r0}$ ) at $(5 \pm 1)$ Hz for 1 000 cycles | MN/m |
| $k_{r,dyn2}$                | low frequency dynamic stiffness on 10 cycles under applying a cyclic force of $F_{r,min}$ (= $0,1 \cdot F_{r0}$ ) to $F_{r,test2}$ (= $F_{r0}$ ) at $(5 \pm 1)$ Hz for 1 000 cycles           | MN/m |
| $k_{1s}$                    | load factor of exceptional test load level                                                                                                                                                    | n/a  |
| $k_{2s}$                    | load factor of accidental test load level                                                                                                                                                     | n/a  |
| $k_3$                       | static coefficient to be used for calculation of $F_{rB}$ at the end of fatigue test and provided by the purchaser                                                                            | n/a  |
| $L_B$                       | shoulder length of ballast bed in a ballast box                                                                                                                                               | mm   |

Table 1 (continued)

| Symbol/<br>Abbreviated term | Description                                                                                                     | Unit |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------|------|
| $L_c$                       | design distance between centre lines of the rail seat                                                           | m    |
| $L_0$                       | length measured on the opposite side of top of sleeper, bearer or transom for Thermal expansion test            | m    |
| $L_p$                       | design distance between the centre line of the rail seat to the edge of the sleeper at the bottom               | m    |
| $L_r$                       | design distance between the articulated supports centre lines for the test arrangement at the rail seat section | m    |
| $L_s$                       | length between the supports on the longitudinal girders of the bridge                                           | m    |
| $L_T$                       | length measured on the top of the sleeper, bearer or transom for Thermal expansion test                         | m    |
| $M_{k,b}$                   | characteristic bending moment for transom                                                                       | kN.m |
| $M_{k,c,neg}$               | negative characteristic bending moment at centre station                                                        | kN.m |
| $M_{k,c,pos}$               | positive characteristic bending moment at centre station                                                        | kN.m |
| $M_{k,r,pos}$               | positive characteristic bending moment at rail seat                                                             | kN.m |
| $Q_{nom}$                   | nominal wheel load (static wheel load)                                                                          | kN   |

## 5 Product characteristics

### 5.1 General

This clause defines the testing regime and rules for the acceptance of polymeric composite sleepers, bearers and transoms.

The bending tests are defined for ballasted track. For ballastless track, the test arrangement shall be reviewed in order to adapt to the real configuration of the track.

### 5.2 Bending resistance

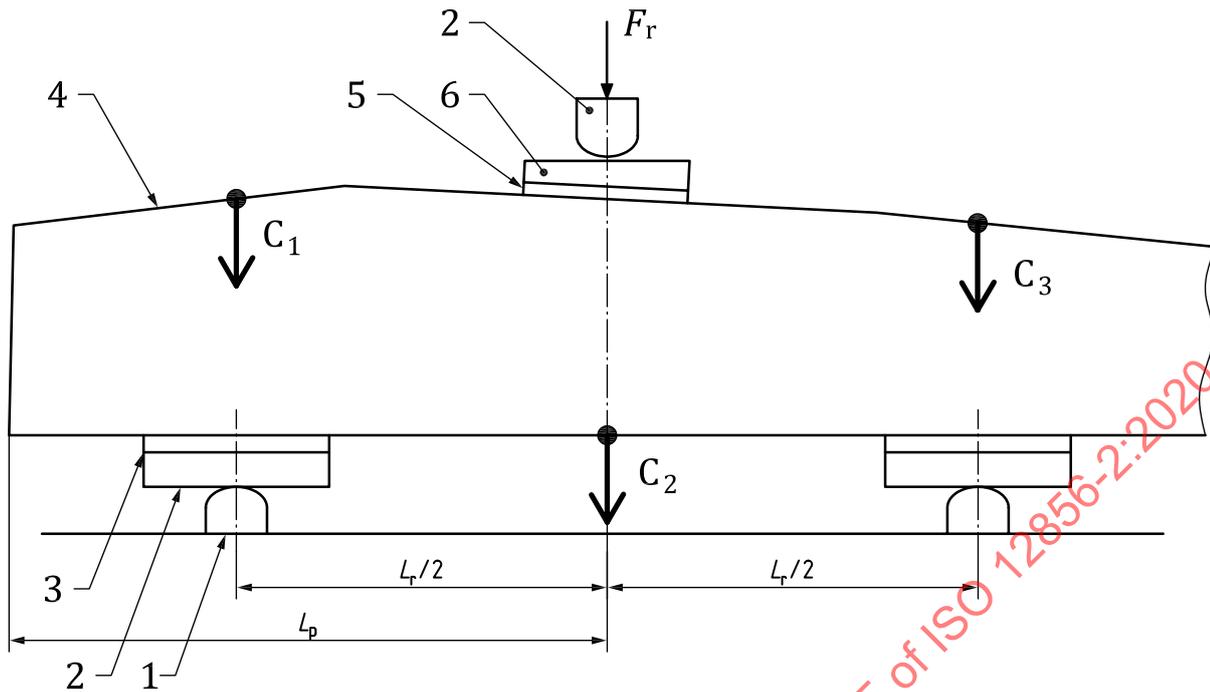
#### 5.2.1 Test arrangements

##### 5.2.1.1 Rail seat section for the positive load test for sleepers

The arrangement for the rail seat positive load test is shown in [Figure 1](#); the value of  $L_r$  in relation to  $L_p$  is detailed in [Table 2](#).

The load,  $F_p$ , is applied perpendicularly to the base of the sleeper.

The end of the sleeper opposite to the end being tested shall not be fixed.



**Key**

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width: 140 ± 1 mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width: 140 + <sup>+10</sup><sub>0</sub> mm, thickness: 15 <sup>+2</sup><sub>-3</sub> mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa: 1 ≤ C ≤ 4 N/mm<sup>3</sup>)
- 4 polymeric composite sleeper without the fastening system and with baseplate (if used)
- 5 standard rail pad as defined by the purchaser
- 6 steel tapered packing compensating the inclination of the rail seat (minimum length: length of the standard rail pad +20 mm, width: 140 ± 1 mm (this width can be reduced in line with the real width of the rail foot used in track), thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> locations of the vertical displacement measurement on the axis of the articulated support
- F<sub>r</sub> positive test load for the rail seat section
- L<sub>r</sub> design distance between the articulated supports centre lines for the test arrangement at the rail seat section
- L<sub>p</sub> design distance between the centre line of the rail seat to the edge of the sleeper at the bottom

**Figure 1 — Test arrangement at the rail seat section for the positive load test**

The deformation, *d*, measured during the tests on the rail seat is calculated with [Formula \(1\)](#):

$$d = C_2 - \frac{C_1 + C_3}{2} \tag{1}$$

Table 2 — Value of  $L_r$  in relation to  $L_p$

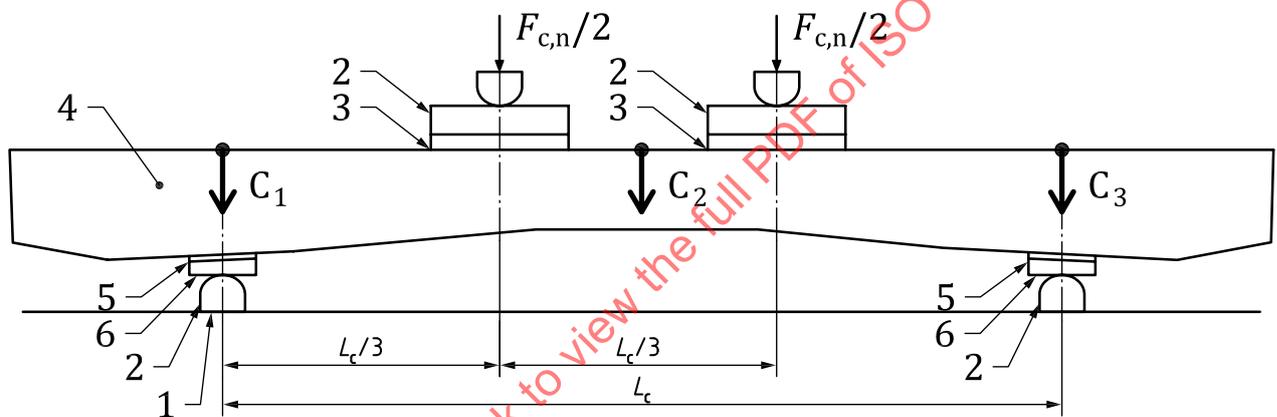
| $L_p$<br>m               | $L_r$<br>m |
|--------------------------|------------|
| $L_p < 0,349$            | 0,3        |
| $0,350 \leq L_p < 0,399$ | 0,4        |
| $0,400 \leq L_p < 0,449$ | 0,5        |
| $L_p \geq 0,450$         | 0,6        |

The displacement measuring instruments shall be capable of measuring the displacement within  $\pm 0,02$  mm.

The force measuring instruments shall conform to ISO 7500-1, class 2, over the required range of force.

### 5.2.1.2 Centre section for the negative load test for sleepers

The arrangement for the negative centre load test is shown in Figure 2.



#### Key

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width:  $140 \pm 1$  mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140^{+10}_0$  mm, thickness:  $15^{+2}_3$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4$  N/mm<sup>3</sup>)
- 4 polymeric composite sleeper with or without the fastening system and the baseplate (if used);
- 5 standard rail pad as defined by the purchaser
- 6 steel tapered packing compensated the inclination of the rail seat (minimum length: length of the standard rail pad +20 mm, width:  $140 \pm 1$  mm [this width can be reduced in line with the real width of the rail foot used in track], thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- $C_1, C_2$  and  $C_3$  locations of the vertical displacement measurement on the axis of the articulated support of the rail seats and the centre of the sleeper
- $F_{c,n}$  negative reference test load at the centre section of the sleeper
- $L_c$  design distance between centre lines of the rail seat

Figure 2 — Test arrangement at the centre section for the negative load test

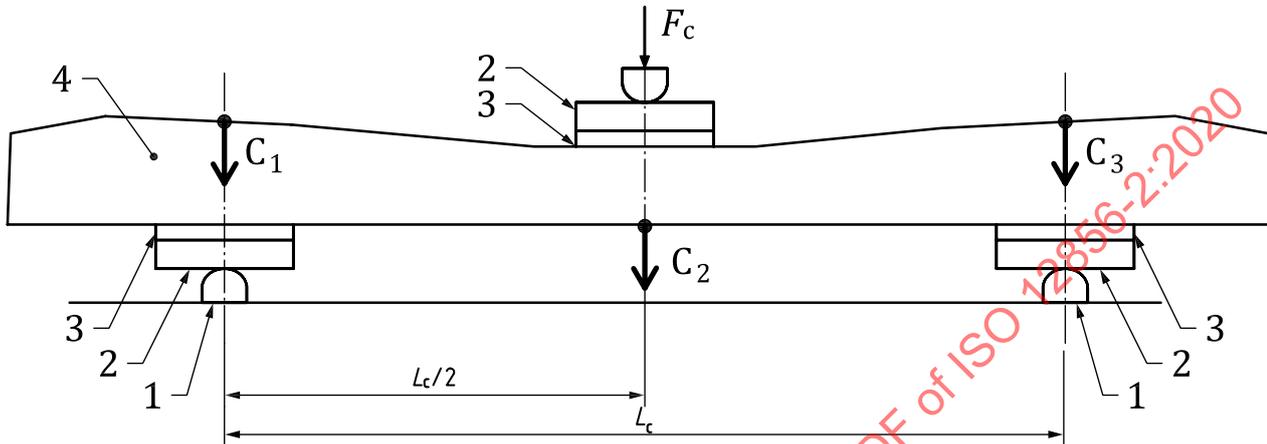
The deformation,  $d$ , measured during the tests on the centre section for the negative load is calculated using Formula (1).

The displacement measuring instruments shall be capable of measuring the displacement within  $\pm 0,02$  mm.

The force measuring instruments shall conform to ISO 7500-1, class 2, over the required range of force.

**5.2.1.3 Centre section for the positive load test for sleepers**

The test arrangement for the positive centre load test is shown in [Figure 3](#).



**Key**

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width:  $140 \pm 1$  mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140^{+10}_0$  mm, thickness:  $15 + \frac{+2}{-3}$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4$  N/mm<sup>3</sup>)
- 4 polymeric composite sleeper with or without the fastening system and without the baseplate
- $C_1, C_2$  and  $C_3$  locations of the vertical displacement measurement on the axis of the articulated support
- $F_c$  positive test load at the centre section of the sleeper
- $L_c$  design distance between centre lines of the rail seat

**Figure 3 — Test arrangement at the centre section for the positive load test**

The deformation,  $d$ , measured during the tests on the centre section for the negative load is calculated using [Formula \(1\)](#).

The displacement measuring instruments shall be capable of measuring the displacement within  $\pm 0,02$  mm.

The force measuring instruments shall conform to ISO 7500-1, class 2, over the required range of force.

**5.2.1.4 Rail seat section for the positive load test for bearers**

The arrangement for the rail seat positive load at a rail seat:

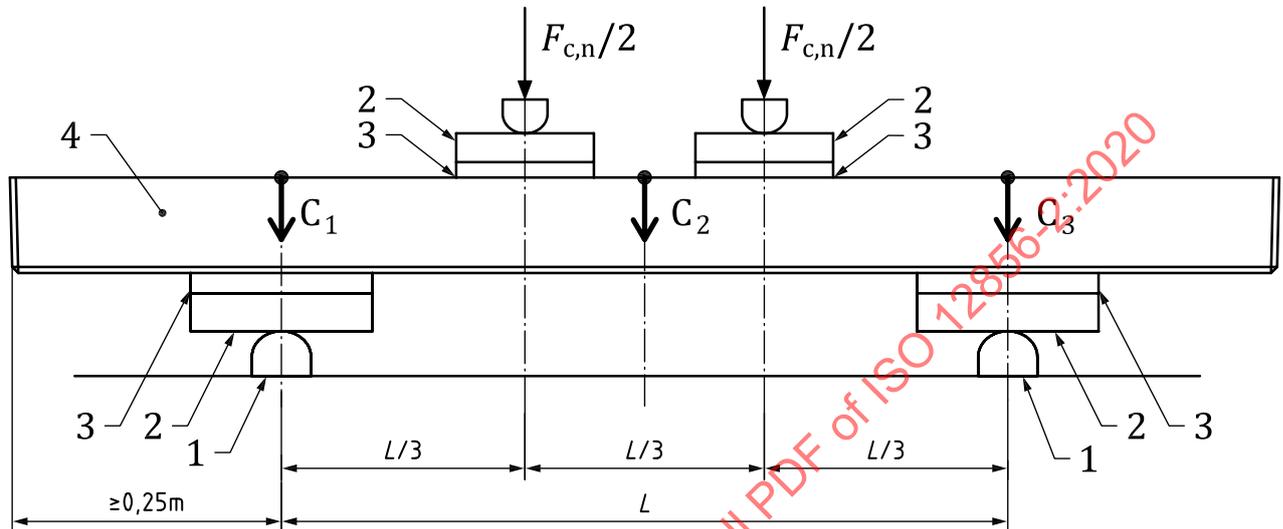
- next to the end of the bearer, and
- with direct support of the rail (i.e. fastening system without a baseplate),

is shown in [Figure 1](#). The value of  $L_r$  in relation to  $L_p$  is detailed in [Table 2](#).

The load,  $F_p$ , is applied perpendicularly to the base of the bearer.

The end of the bearer opposite to the end being tested shall be supported during the test in order to compensate the influence of the weight of the bearers on the test bending moment. Alternatively, the bearer may be cut off at the distance,  $L_p$ , from the centre line of the rail.

### 5.2.1.5 Centre section for the negative load test for bearers

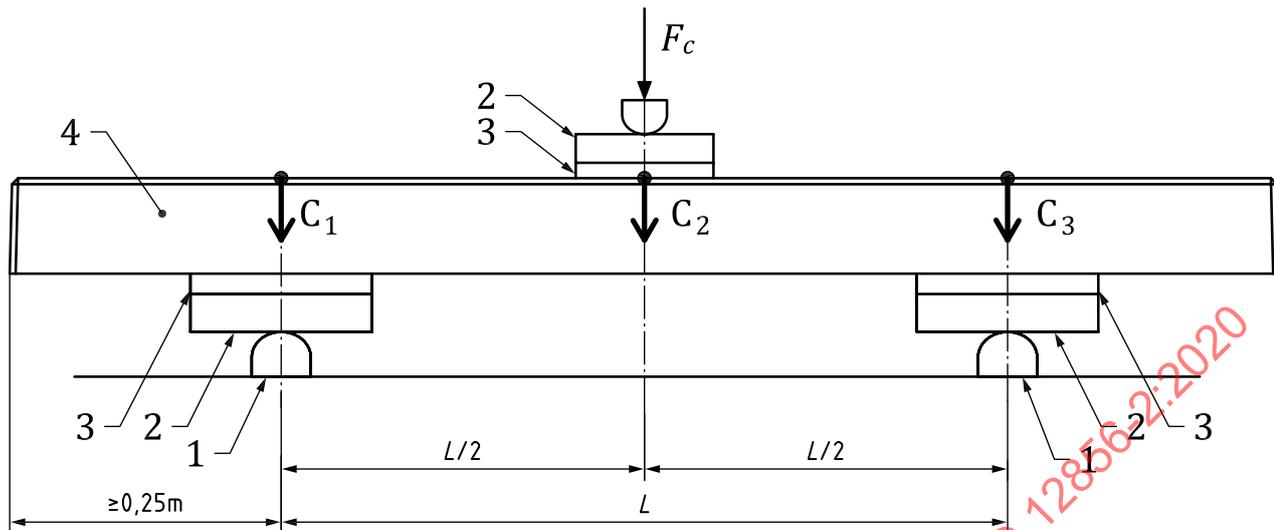


#### Key

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width:  $140 \pm 01$  mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140 \begin{smallmatrix} +10 \\ 0 \end{smallmatrix}$  mm, thickness:  $15 \begin{smallmatrix} +2 \\ -3 \end{smallmatrix}$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4$  N/mm<sup>3</sup>)
- 4 polymeric composite bearer without the fastening system and with the baseplate (if used)
- $L_C$  for gauges of 1 435 mm,  $L = 1,5$  m. For other gauges, the length shall be adapted
- $C_1, C_2$  and  $C_3$  locations of the vertical displacement measurement on the axis of the articulated support
- $F_{C,n}$  negative test load at the centre section of the sleeper

**Figure 4 — Test arrangement at the centre section for the negative load test**

5.2.1.6 Centre section for the positive load test for bearers



Key

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width:  $140 \pm 1$  mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140^{+10}_0$  mm, thickness:  $15^{+2}_3$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4 \text{ N/mm}^3$ )
- 4 polymeric composite bearer without the fastening system and with the baseplate (if used)
- $L$  for gauges of 1 435 mm,  $L = 1,5$  m. For other gauges, the length shall be adapted
- $C_1, C_2$  and  $C_3$  locations of the vertical displacement measurement on the axis of the articulated support
- $F_c$  positive test load at the centre section of the sleeper

Figure 5 — Test arrangement at the centre section for the positive load test

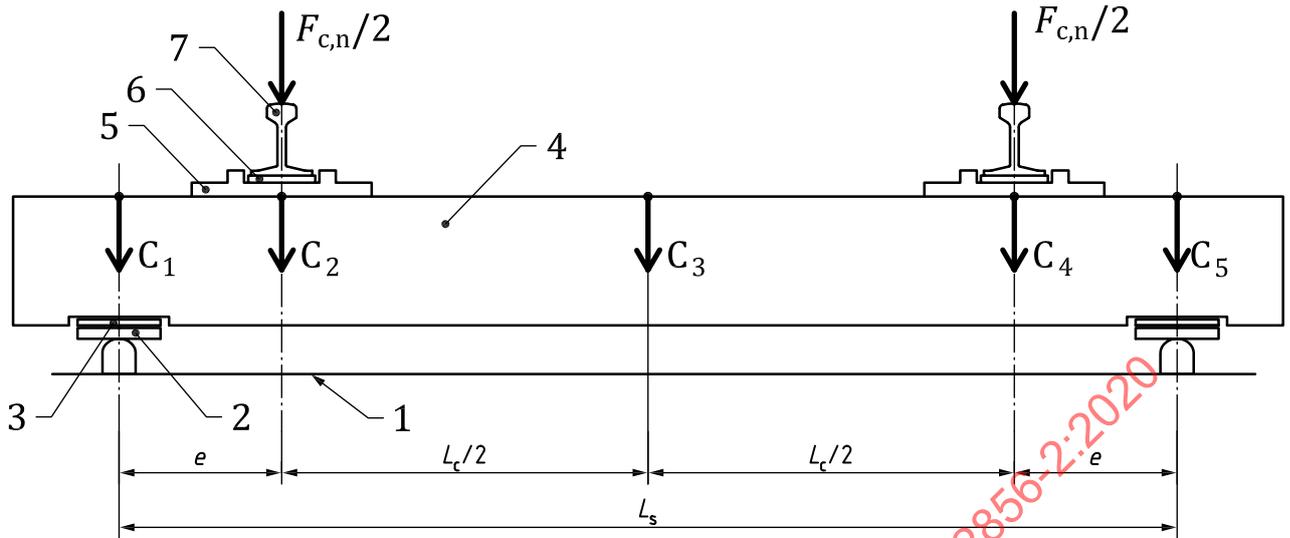
5.2.1.7 Centre section for the load test for transom

The test arrangement shall be approved by the purchaser, depending on the bridge.

NOTE This test arrangement generates positive or negative bending moments depending on the eccentricity,  $e$ , of the supports on the longitudinal girders of the bridge. However, this test arrangement is only used for the tests in 5.2.3, "Test procedures at the centre section for the negative bending moments".

If support conditions for the transoms on the bridge are different to the test arrangement in Figure 6, this should be taken into account in the calculation of  $M_{k,b}$ .

Any modification (for example cut-outs to fasten the transom) should be carried out on the transom before testing.


**Key**

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140 \pm 1$  mm [this width can be reduced in line with the real width of the rail foot used in track], thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140 +^{10}_0$  mm, thickness:  $15 +^2_3$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4$  N/mm<sup>3</sup>)
- 4 transom
- 5 rib plate as defined by the purchaser
- 6 standard rail pad as defined by the purchaser
- 7 rail as defined by the purchaser
- e* design distance between the centre line of the rail seat to the longitudinal girders of bridge
- $L_s$  length between the supports on the longitudinal girders of the bridge
- $C_1, C_2, C_3, C_4$  and  $C_5$  locations of the vertical displacement measurement on the axis of the articulated support
- $F_{c,n}$  negative test load at the centre section of the sleeper
- $L_c$  design distance between centre lines of the rail seat

**Figure 6 — Test arrangement at the centre section for the load test**

The deformation,  $d$ , measured during the tests on the rail seat is calculated with the [Formulae \(2\), \(3\) and \(4\)](#):

$$d = C_2 - \left[ C_5 + (C_1 - C_5) \cdot \frac{L_s - e}{L_s} \right] \text{ (at left rail seat)} \quad (2)$$

$$d = C_4 - \left[ C_5 + (C_1 - C_5) \cdot \frac{e}{L_s} \right] \text{ (at right rail seat)} \quad (3)$$

$$d = C_3 - \frac{(C_1 + C_5)}{2} \text{ (at sleeper centre)} \quad (4)$$

5.2.2 Initial reference test loads

5.2.2.1 Initial reference test loads for sleepers

$F_{r0}$  is calculated from the geometry given in [Figure 1](#) and values from [Table 3](#) using [Formula \(5\)](#):

$$F_{r0} = \frac{4M_{k,r,pos}}{L_r - 0,1} \text{ (in kN)} \tag{5}$$

**Table 3 — Value of  $F_{r0}$  in relation to  $L_r$**

|                |                  |                  |                  |                 |
|----------------|------------------|------------------|------------------|-----------------|
| $L_r$<br>m     | 0,3              | 0,4              | 0,5              | 0,6             |
| $F_{r0}$<br>kN | $20 M_{k,r,pos}$ | $13 M_{k,r,pos}$ | $10 M_{k,r,pos}$ | $8 M_{k,r,pos}$ |

$F_{c0}$  and  $F_{c0,n}$  are calculated from the geometry given respectively in [Figures 2](#) and [3](#) using [Formulae \(6\)](#) and [\(7\)](#):

$$F_{c0} = \frac{4M_{k,c,pos}}{L_c - 0,1} \text{ (in kN)} \tag{6}$$

$$F_{c0,n} = \frac{6M_{k,c,neg}}{L_c} \text{ (in kN)} \tag{7}$$

5.2.2.2 Initial reference test loads for bearers

$F_{r0}$  is calculated from the geometry given in [Figure 1](#) and values from [Table 3](#) using [Formula \(5\)](#) with  $L_r = 0,6$  m.

$F_{c0}$  and  $F_{c0,n}$  are calculated from the geometry given respectively in [Figures 4](#) and [5](#) using [Formulae \(6\)](#) and [\(7\)](#) with  $L_c = 1,5$  m for a gauge of 1 435 mm. For other gauges, the length shall be adapted.

5.2.2.3 Initial reference test load for transoms

$F_{c0,n}$  are calculated from the geometry given respectively in [Figure 6](#) using [Formula \(8\)](#).

$$F_{c0,n} = \frac{2 \cdot M_{k,b}}{e} \tag{8}$$

5.2.3 Test procedures at the centre section for the negative bending moments

5.2.3.1 Stiffness at the centre section

The stiffness test at the centre section for the design approval test is performed by applying a load with measurement of the deformation of the sleeper, bearer or transom.

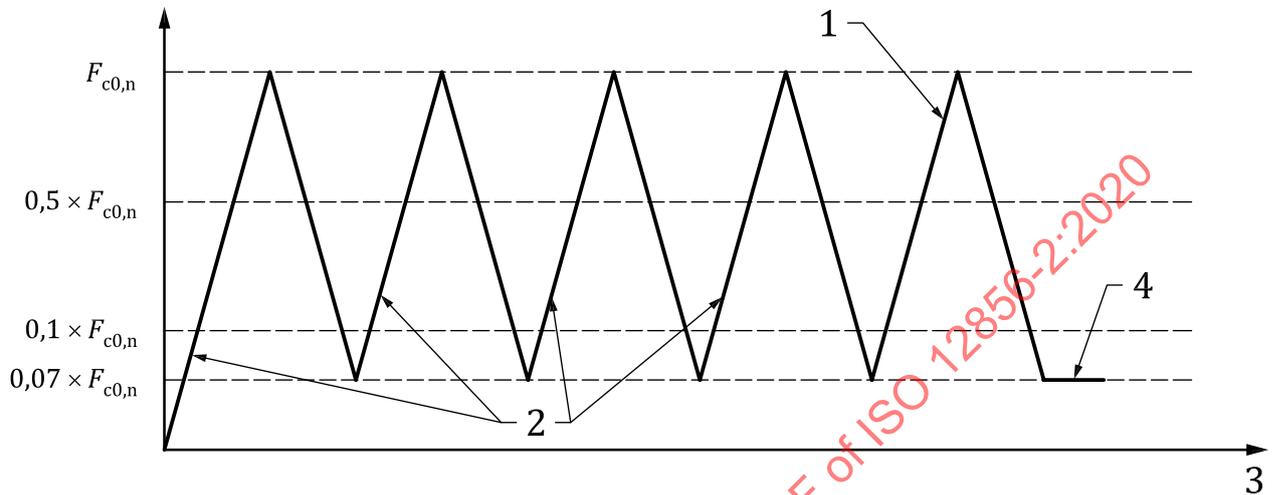
The test arrangement shall be in accordance with [5.2.1.2](#) for sleepers, with [5.2.1.5](#) for bearers and with [5.2.1.7](#) for transoms.

The static and dynamic stiffness tests shall be carried out at a room temperature of  $(23 \pm 5)$  °C if no specific temperature has been fixed by the purchaser.

NOTE Control of room temperature is important for establishing an accurate result. Any variation beyond set tolerances affects the result.

Static stiffness:

Apply a vertical force  $F_{c0,n}$  to the actuator. Then reduce the force to  $(0,07 \cdot F_{c0,n})$  and repeat this cycle of loading and unloading three more times with a speed of between 60 and 120 kN/min. Maintain the applied force  $(0,07 \cdot F_{c0,n})$ , then record the displacement as a function of the load whilst increasing the applied force to  $F_{c0,n}$  (this loading corresponds to the fifth loading).



**Key**

- 1 fifth loading: temporal laps to record the displacement whilst increasing the applied force to  $F_{c0,n}$
  - 2 four first loadings: preconditioning
  - 3 time
  - 4 if a dynamic stiffness is measured after the static stiffness test, the force is maintained at  $0,07 F_{c0,n}$
- $F_{c0,n}$  negative reference test load at the centre section of the sleeper

**Figure 7 — Loading cycle of static stiffness positive bending at centre section**

Calculate the static stiffness of the fifth loading from [Formulae \(9\)](#) and [\(10\)](#):

$$k_{c,n,stat1} = \frac{0,4 \cdot F_{c0,n}}{\Delta d_1} \tag{9}$$

$$k_{c,n,stat2} = \frac{0,9 \cdot F_{c0,n}}{\Delta d_2} \tag{10}$$

where

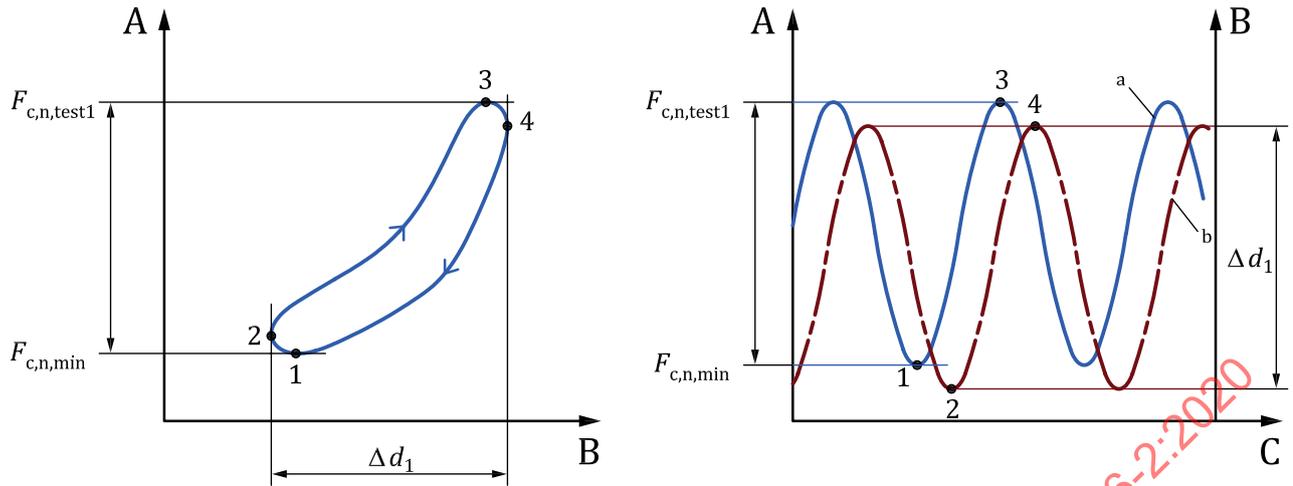
$\Delta d_1$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{c0,n})$  and  $(0,5 \cdot F_{c0,n})$ ;

$\Delta d_2$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{c0,n})$  and  $F_{c0,n}$ .

The report shall include:  $F_{c0,n}$ ,  $k_{c,n,stat1}$ ,  $k_{c,n,stat2}$  and a graph showing the deformation of the sleeper in function of the load  $F_{c,n}$ .

Dynamic stiffness  $k_{c,n,dyn1}$ :

Apply a cyclic force  $F_{c,n,min} (= 0,1 \cdot F_{c0,n})$  to  $F_{c,n,test1} (= 0,5 \cdot F_{c0,n})$  at  $(5 \pm 1)$  Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper for at least 10 cycles.



- Key**
- A force
  - B displacement
  - C time
  - a force
  - b displacement

**Figure 8 — Low frequency dynamic curves**

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(11\)](#):

$$k_{c,n,dyn1} = \frac{1}{10} \cdot \sum_{10} \frac{F_{c,n,test1} - F_{c,n,min}}{\Delta d_1} \tag{11}$$

where  $\Delta d_1$  is the variation of deformation of the sleeper between the loads ( $F_{c,n,min}$ ) and ( $F_{c,n,test1}$ ).

The report shall include: ( $0,5 \cdot F_{c0,n}$ ),  $k_{c,n,dyn1}$  and a graph showing the deformation of the sleeper as a function of the load,  $F_{c,n}$ .

Dynamic stiffness  $k_{c,n,dyn2}$ :

Apply a cyclic force of  $F_{c,n,min}$  ( $= 0,1 \cdot F_{c0,n}$ ) to  $F_{c,n,test2}$  ( $= F_{c0,n}$ ) at ( $5 \pm 1$ ) Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper for at least 10 cycles.

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(12\)](#):

$$k_{c,n,dyn2} = \frac{1}{10} \cdot \sum_{10} \frac{F_{c,n,test2} - F_{c,n,min}}{\Delta d_2} \tag{12}$$

where  $\Delta d_2$  is the variation of deformation of the sleeper between the loads ( $F_{c,n,min}$ ) and ( $F_{c,n,test2}$ ).

The report shall include:  $F_{c0,n}$ ,  $k_{c,n,dyn2}$  and a graph showing the deformation of the sleeper as a function of the load,  $F_{c,n}$ .

**5.2.3.2 Fatigue test and ultimate load at the centre section for negative bending moments**

Before the fatigue test at the centre section for negative bending moments, the static and dynamic stiffness tests shall be carried out in accordance with [5.2.3.1](#).

The test arrangement shall be in accordance with [5.2.1.2](#) for sleepers, with [5.2.1.5](#) for bearers and with [5.2.1.7](#) for transoms.

The tests shall be carried out at a room temperature of  $(23 \pm 5) ^\circ\text{C}$  if no specific temperature has been fixed by the purchaser.

NOTE 1 Control of room temperature is important for establishing an accurate result. Any variation beyond set tolerances affects the result.

The test bending moment and the acceptable displacement,  $d_{fat,lim}$ , shall be defined as a function of maintenance policy. The test load,  $F_{c,fat,n}$ , shall be the lesser of either the test load  $F_{c0,n}$  or the load leading to the acceptable displacement. If, during the test, the deflection in the centre of the sleeper exceeds the acceptable deflection defined by the purchaser, the test shall be stopped.

In case acceptable displacement is exceeded in the test, it is recommended to test the sleeper in a ballast box according to [5.7](#).

The fatigue test at the centre section for negative bending moments for the design approval test is performed by applying a sinusoidal load between  $(0,1 \cdot F_{c,fat,n})$  and  $F_{c,fat,n}$  at a frequency,  $f$ , of 5 Hz and for 2 000 000 cycles.

If no other test method is defined by the purchaser, the following procedure shall be used: apply the sinusoidal test load for 45 s. After that, wait 90 s with a constant load of 1 kN. Then apply the sinusoidal load again at the chosen frequency for 45 s. Then wait 90 s without load, etc. The test arrangement shall be in accordance with [5.2.1.2](#) for sleepers, with [5.2.1.5](#) for bearers and with [5.2.1.7](#) for transoms. During the fatigue test, the temperature of all points of the sleeper shall be less than  $40 ^\circ\text{C}$  for a room temperature of  $(23 \pm 5) ^\circ\text{C}$ .

NOTE 2 The maximum temperature usually occurs under the fastening system.

If the temperature of the sleeper reaches  $40 ^\circ\text{C}$ , the waiting time should be increased in order to limit the maximum temperature. If the waiting time is changed, the value should be documented in the test report.

Temperatures above  $40 ^\circ\text{C}$  can severely affect the test and therefore the results obtained.

The purchaser may change the number of cycles for the fatigue test and/or the test load level,  $F_{c,fat,n}$ .

If the purpose of the fatigue test is destruction of the specimen tested, the stiffness tests may be omitted.

If required by the purchaser, during loading, the deformation of the sleeper is measured as a function of the load,  $F_{c,n}$ , after the first 1 000 cycles and after every 100 000 cycles for a fatigue test of 2 000 000 cycles.

At least 24 hours after the 2 000 000 cycles, the static and dynamic stiffness tests shall be carried out in accordance with [5.2.3.1](#) at a room temperature of  $(23 \pm 5) ^\circ\text{C}$ . The sleeper shall be kept at room temperature before the stiffness tests for at least 24 hours.

After the fatigue test, increase the load to failure or maximum deflection of 20 mm of the sleeper (whichever occurs first) with a speed of between 60 and 120 kN/min.

The report shall include:

- a displacement-force diagram according to the test setup as per [5.2.3.1](#) during the 2 000 000 cycles;
- the stiffness results;
- the variation of static and dynamic stiffness ( $\Delta k_{c,n}$ ) before and after the fatigue test; and
- the break load or the load for 20 mm of deflection.

### 5.2.3.3 Permanent deformation test at the centre section for negative bending moments

The permanent deformation test at the centre section for negative bending moments for the design approval test is performed by applying a constant load of  $F_{c,perm,n}$  for a period of 168 hours, or the load

leading to the acceptable deflection, whichever is lower. The test arrangement shall be in accordance with 5.2.1.2 for sleepers, with 5.2.1.5 for bearers and with 5.2.1.7 for transoms. The acceptable displacement is a function of maintenance policy and shall be defined by the purchaser.

The deformation at the centre of the sleeper is measured before loading, every 24 hours during the loading, just after removal of the load and every 24 hours after removal of the load during the 168 hour period.

The report shall include the deformation during the two weeks of the test and the test load applied.

#### 5.2.3.4 Strength test at the centre section for negative bending moments

The strength test at the centre section for the design approval test is performed by applying a static load to failure or maximum deflection of 20 mm of the sleeper with a speed of between 60 and 120 kN/min.

The maximum load is documented in the test report. The strength test shall be carried out in accordance with 5.2.1.2 for sleepers, with 5.2.1.5 for bearers and with 5.2.1.7 for transoms.

#### 5.2.4 Test procedures at the centre section for the positive bending moments

##### 5.2.4.1 Stiffness at the centre section

The stiffness test at the centre section for the design approval test is performed by applying a load with measurement of the deformation of the sleeper and of the bearer.

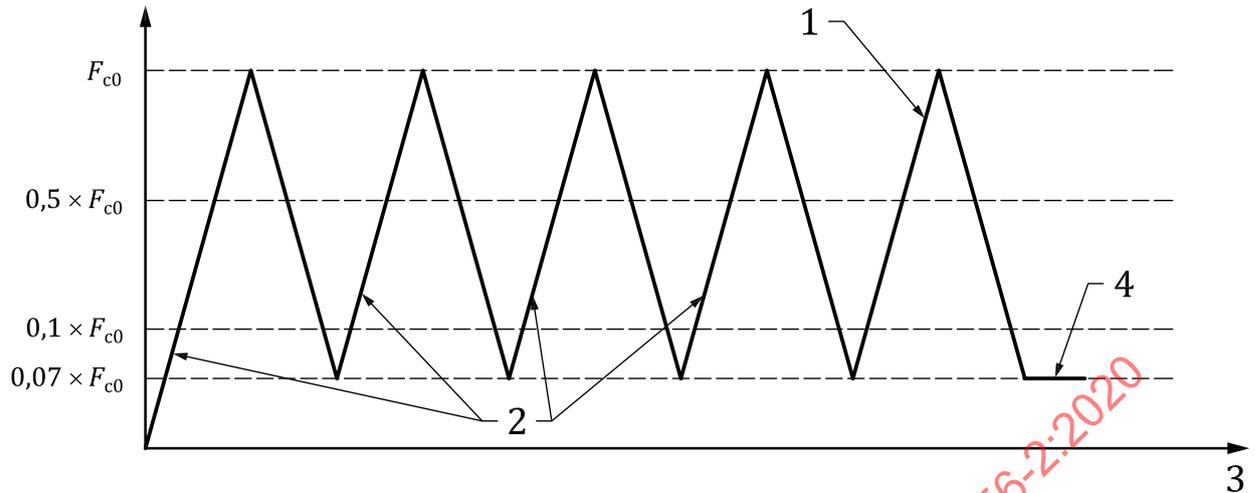
The test arrangement shall be in accordance with 5.2.1.3 for sleepers and with 5.2.1.6 for bearers.

The static and dynamic stiffness tests shall be carried out at a room temperature of  $(23 \pm 5)$  °C if no specific temperature has been fixed by the purchaser.

NOTE Control of room temperature is important to establish an accurate result. Any variation beyond set tolerances affects the result.

##### Static stiffness:

Apply a vertical force  $F_{c0}$  to the actuator. Then reduce the force to  $(0,07 \cdot F_{c0})$  and repeat this cycle of loading and unloading three more times with a speed between 60 and 120 kN/min. Maintain the applied force  $(0,07 \cdot F_{c0})$ , then record the displacement as a function of the load whilst increasing the applied force to  $F_{c0}$  (this loading corresponds to the fifth loading).

**Key**

- 1 fifth loading: temporal laps to record the displacement whilst increasing the applied force to  $F_{c0}$
  - 2 four first loadings: preconditioning
  - 3 time
  - 4 if a dynamic stiffness is measured after the static stiffness test, the force is maintained to  $0,07 F_{c0}$
- $F_{c0}$  positive reference test load at the centre section of the sleeper

**Figure 9 — Loading cycle of static stiffness negative bending at centre section**

Calculate the static stiffness of fifth loading from the following [Formulae \(13\)](#) and [\(14\)](#):

$$k_{c,stat1} = \frac{0,4 \cdot F_{c0}}{\Delta d_1} \quad (13)$$

$$k_{c,stat2} = \frac{0,9 \cdot F_{c0}}{\Delta d_2} \quad (14)$$

where

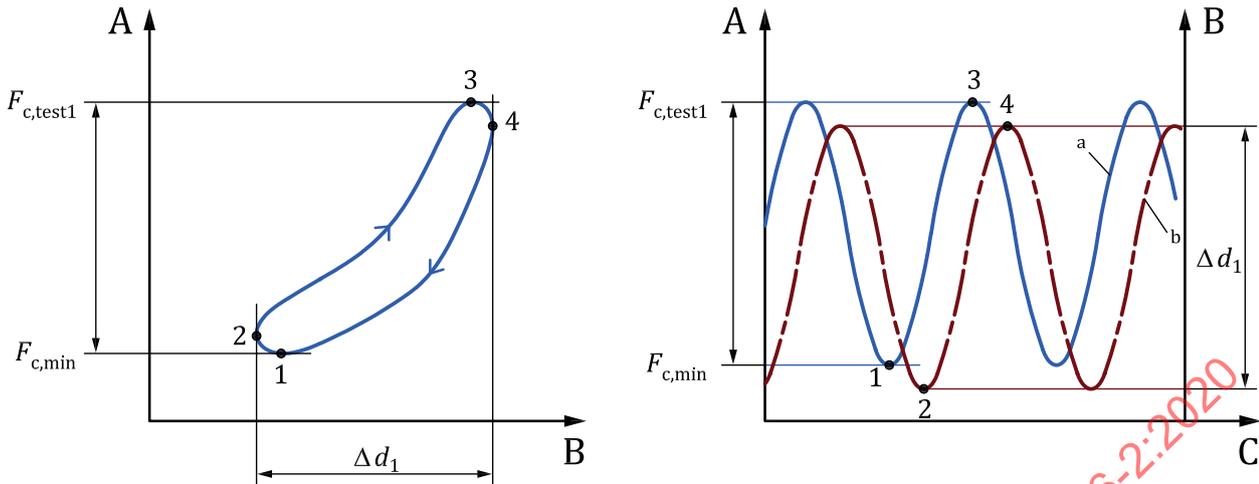
$\Delta d_1$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{c0})$  and  $(0,5 \cdot F_{c0})$ ;

$\Delta d_2$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{c0})$  and  $F_{c0}$ .

The report shall include:  $F_{c0}$ ,  $k_{c,stat1}$ ,  $k_{c,stat2}$  and a graph showing the deformation of the sleeper in function of the load,  $F_c$ .

Dynamic stiffness  $k_{c,dyn1}$ :

Apply a cyclic force of  $F_{c,min}$  ( $= 0,1 \cdot F_{c0}$ ) to  $F_{c,test1}$  ( $= 0,5 \cdot F_{c0}$ ) at  $(5 \pm 1)$  Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper for at least 10 cycles.



**Key**

- A force
- B displacement
- C time
- a force
- b displacement
- $F_{c,test1}$  maximum test load
- $F_{c,min}$  minimum test load
- $\Delta d_1$  variation of deformation of the sleeper between the loads

**Figure 10 — Low frequency dynamic curves**

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(15\)](#):

$$k_{c,dyn1} = \frac{1}{10} \cdot \sum_{10} \frac{F_{c,test1} - F_{c,min}}{\Delta d_1} \tag{15}$$

where  $\Delta d_1$  is the variation of deformation of the sleeper between the loads,  $F_{c,min}$  and  $F_{c,test1}$ .

The report shall include:  $(0,5 \cdot F_{c0,n})$ ,  $k_{c,dyn1}$  and a graph showing the deformation of the sleeper as a function of the load,  $F_c$ .

Dynamic stiffness  $k_{c,dyn2}$ :

Apply a cyclic force of  $F_{c,min}$  ( $= 0,1 \cdot F_{c0}$ ) to  $F_{c,test2}$  ( $= F_{c0}$ ) at  $(5 \pm 1)$  Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper for at least 10 cycles.

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(16\)](#):

$$k_{c,dyn2} = \frac{1}{10} \cdot \sum_{10} \frac{F_{c,test2} - F_{c,min}}{\Delta d_2} \tag{16}$$

where  $\Delta d_2$  is the variation of deformation of the sleeper between the loads,  $F_{c,min}$  and  $F_{c,test2}$ .

The report shall include:  $F_{c0}$ ,  $k_{c,dyn2}$  and a graph showing the deformation of the sleeper as a function of the load  $F_c$ .

#### 5.2.4.2 Fatigue test and ultimate load at the centre section for positive bending moments

Before the fatigue test at the centre section for positive bending moments, the static and dynamic stiffness tests shall be carried out in accordance with 5.2.4.1 at a room temperature of  $(23 \pm 5) ^\circ\text{C}$ .

The test arrangement shall be in accordance with 5.2.1.3 for sleepers and with 5.2.1.6 for bearers.

The tests shall be carried out at a room temperature of  $(23 \pm 5) ^\circ\text{C}$  if no specific temperature has been fixed by the purchaser.

NOTE Control of room temperature is important for establishing an accurate result. Any variation beyond set tolerances affects the result.

The test bending moment and the acceptable displacement,  $d_{fat,lim}$ , shall be defined as a function of maintenance policy. The test load,  $F_{c,fat}$ , shall be the lesser of either the test load,  $F_{c0}$ , or the load leading to the acceptable displacement. If, during the test, the deflection in the centre of the sleeper exceeds the acceptable deflection defined by the purchaser, the test shall be stopped.

In case acceptable displacement is exceeded in the test, it is recommended to test the sleeper in a ballast box according to 5.7.

The fatigue test at the centre section for negative bending moments for design approval test is performed by applying a sinusoidal load between  $(0,1 \cdot F_{c,fat})$  and  $F_{c,fat}$  at a frequency,  $f$ , of 5 Hz and for 2 000 000 cycles.

If no other test method is defined by the purchaser, the following procedure shall be used: apply the sinusoidal test load for 45 s. After that, wait 90 s with a constant load of 1 kN. Then, apply the sinusoidal load again at the chosen frequency for 45 s. Then wait 90 s without load, etc. The test arrangement shall be in accordance with 5.2.1.3. During the fatigue test, the temperature of the sleeper shall be less than  $40 ^\circ\text{C}$  for a room temperature of  $(23 \pm 5) ^\circ\text{C}$ .

If the temperature of the sleeper reaches  $40 ^\circ\text{C}$ , the waiting time should be increased in order to limit the maximum temperature. If the waiting time is changed, the value should be documented in the test report.

Temperatures above  $40 ^\circ\text{C}$  can severely affect the test and therefore the results obtained.

The purchaser may change the number of cycles for the fatigue test and/or the test load level,  $F_{c,fat}$ .

If the purpose of the fatigue test is destruction of the specimen tested, the stiffness tests may be omitted.

If required by the purchaser, during loading, the deformation of the sleeper is measured as a function of the load,  $F_c$ , after the first thousand cycles and after every 100 000 cycles for a fatigue test of 2 000 000 cycles.

At least 24 hours after the 2 000 000 cycles, the static and dynamic stiffness tests shall be carried out in accordance with 5.2.4.1 at a room temperature of  $(23 \pm 5) ^\circ\text{C}$ . The sleeper shall be kept at room temperature for at least 24 hours before the stiffness tests.

If required by the purchaser, after the fatigue test, increase the load to failure or maximum deflection of 20 mm of the sleeper with a speed between 60 and 120 kN/min.

The report shall include the following elements:

- a graph showing the displacement of the actuator as a function of the load,  $F_c$ , during the 2 000 000 cycles;
- the stiffness results;
- the variation of static and dynamic stiffness,  $(\Delta k_s)$ , before and after the fatigue test; and
- the break load or the load for 20 mm of deflection.

5.2.4.3 Strength test at the centre section for positive bending moments

The strength test at the centre section for the design approval test is performed by applying a static load to failure or maximum deflection of 20 mm of the sleeper with a speed between 60 and 120 kN/min.

The maximum load is documented in the test report. The strength test shall be carried out in accordance with 5.2.1.3.

5.2.5 Test procedures at the rail seat

5.2.5.1 Stiffness at the rail seat

The stiffness test at the rail seat section for the design approval test is performed by applying a load at the rail seat and measuring the deformation of the sleeper, bearer or transom.

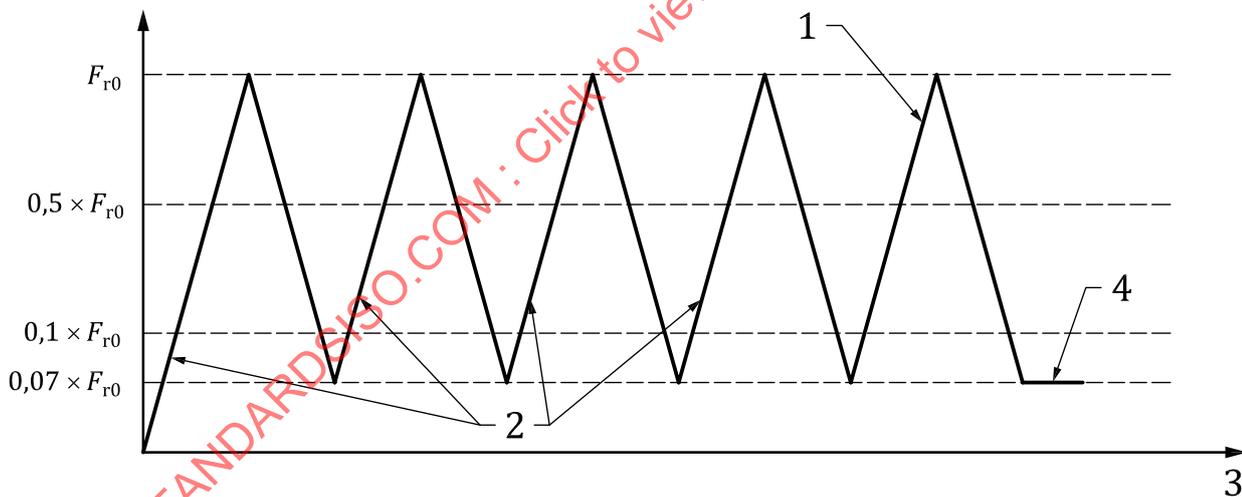
The test arrangement shall be in accordance with 5.2.1.1.

The static and dynamic stiffness tests shall be carried out at a room temperature of  $(23 \pm 5) \text{ }^\circ\text{C}$  if no specific temperature has been fixed by the purchaser.

NOTE Control of room temperature is important for establishing an accurate result. Any variation beyond set tolerances affects the result.

Static stiffness:

Apply a vertical force,  $F_{r0}$ , in the actuator. Then reduce the force to  $(0,07 \cdot F_{r0})$  and repeat this cycle of loading and unloading three more times with a speed between 60 and 120 kN/min. Maintain the applied force  $(0,07 \cdot F_{r0})$ , then record the displacement as a function of the load whilst increasing the applied force to  $F_{r0}$  (this loading corresponds to the fifth loading).



Key

- 1 fifth loading: temporal laps to record the displacement whilst increasing the applied force to  $F_{r0}$
  - 2 four first loadings: preconditioning
  - 3 time
  - 4 if a dynamic stiffness is measured after the static stiffness test, the force is maintained to  $0,07 F_{r0}$
- $F_{r0}$  positive reference test load for the rail seat section

Figure 11 — Loading cycle of static stiffness at rail seat

Calculate the static stiffness of fifth loading from [Formulae \(17\)](#) and [\(18\)](#):

$$k_{r,stat1} = \frac{0,4 \cdot F_{r0}}{\Delta d_1} \tag{17}$$

$$k_{r,stat2} = \frac{0,9 \cdot F_{r0}}{\Delta d_2} \tag{18}$$

where

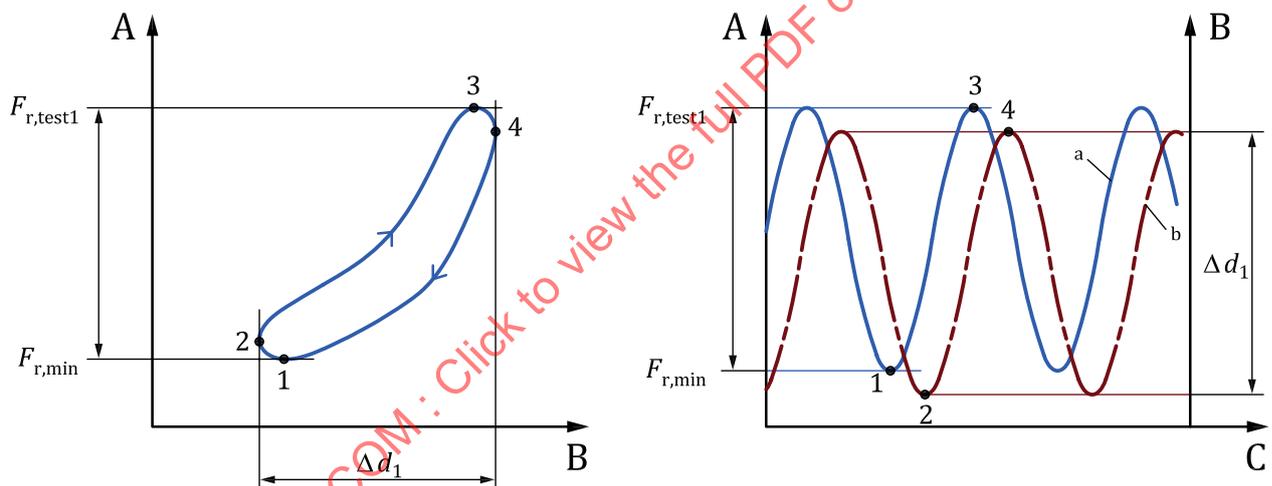
$\Delta d_1$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{r0})$  and  $(0,5 \cdot F_{r0})$ ;

$\Delta d_2$  is the variation of deformation of the sleeper between the loads  $(0,1 \cdot F_{r0})$  and  $F_{r0}$ .

The report shall include:  $F_{r0}$ ,  $k_{r,stat1}$ ,  $k_{r,stat2}$  and a graph showing the deformation of the sleeper as a function of the load,  $F_r$ .

**Dynamic stiffness  $k_{r,dyn1}$ :**

Apply a cyclic force of  $F_{r,min}$  ( $= 0,1 \cdot F_{r0}$ ) to  $F_{r,test1}$  ( $= 0,5 \cdot F_{r0}$ ) at  $(5 \pm 1)$  Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper for at least 10 cycles.



**Key**

- A force
- B displacement
- C time
- $F_{r,test1}$  maximum test load
- $F_{r,min}$  minimum test load
- $\Delta d_1$  variation of deformation of the sleeper between the loads

**Figure 12 — Low frequency dynamic curves**

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(19\)](#):

$$k_{r,dyn1} = \frac{1}{10} \sum_{10} \frac{F_{r,test1} - F_{r,min}}{\Delta d_1} \tag{19}$$

where  $\Delta d_1$  is the variation of deformation of the sleeper between the loads  $(F_{r,min})$  and  $(F_{r,test1})$ .

The report shall include:  $F_{r0}$ ,  $k_{r,dyn1}$  and a graph showing the deformation of the sleeper as a function of the load  $F_r$ .

Dynamic stiffness  $k_{r,dyn2}$ :

Apply a cyclic force of  $F_{r,min}$  ( $= 0,1 \cdot F_{r0}$ ) to  $F_{r,test2}$  ( $=F_{r0}$ ) at  $(5 \pm 1)$  Hz for 1 000 cycles. During the last 100 cycles, record the applied load and the deformation of the sleeper at least 10 cycles.

Calculate the low frequency dynamic stiffness on 10 cycles recorded from [Formula \(20\)](#):

$$k_{r,dyn2} = \frac{1}{10} \cdot \sum_{10} \frac{F_{r,test2} - F_{r,min}}{\Delta d_2} \quad (20)$$

where  $\Delta d_2$  is the variation of deformation of the sleeper between the loads  $F_{r,min}$  and  $F_{r,test2}$ .

The report shall include:  $F_{r0}$ ,  $k_{r,dyn2}$  and a graph showing the deformation of the sleeper as a function of the load,  $F_r$ .

**5.2.5.2 Fatigue test at the rail seat**

Before the fatigue test at the rail seat section, the static and dynamic stiffness tests are carried out in accordance with [5.2.5.1](#) at a room temperature of  $(23 \pm 5)$  °C.

The test arrangement shall be in accordance with [5.2.1.1](#).

The tests shall be carried out at a room temperature of  $(23 \pm 5)$  °C if no specific temperature has been fixed by the purchaser.

NOTE Control of room temperature is important for establishing an accurate result. Any variation beyond set tolerances affects the result.

The test bending moment and the acceptable displacement,  $d_{fat,lim}$ , shall be defined as a function of maintenance policy. The test load,  $F_{r,fat}$ , shall be the lesser of either the test load,  $F_{r0}$ , or the load leading to the acceptable displacement. If, during the test, the deflection in the centre of the sleeper exceeds the acceptable deflection defined by the purchaser, the test shall be stopped.

In case acceptable displacement is exceeded in the test, it is recommended to test the sleeper in a ballast box according to [5.7](#).

The fatigue test at the centre section for negative bending moments for the design approval test is performed by applying a sinusoidal load between  $(0,1 \cdot F_{r,fat})$  and  $F_{r,fat}$  at a frequency,  $f$ , of 5 Hz and for 2 000 000 cycles.

If no other test method is defined by the purchaser, the following procedure shall be used: apply the sinusoidal test load for 45 seconds. After that, wait 90 s with a constant load of 1 kN. Then, apply the sinusoidal load at the chosen frequency again for 45 s. Then wait 90 s without load, etc. The test arrangement shall be in accordance with [5.2.1.1](#). During the fatigue test, the temperature of the sleeper, bearer or transom shall be less than 40 °C for a room temperature of  $(23 \pm 5)$  °C.

If the temperature of the sleeper reaches 40 °C, the waiting time should be increased in order to limit the maximum temperature. If the waiting time is changed, the value should be documented in the test report.

Temperatures above 40 °C can severely affect the test and therefore the results obtained.

The purchaser may change the number of cycles for the fatigue test or/and the test load level,  $F_{r,fat}$ .

If the purpose of the fatigue test is destruction of the specimen tested, the stiffness tests may be omitted.

If required by the purchaser, during loading, the deformation of the sleeper is measured as a function of the load,  $F_r$ , after the first thousand cycles and after every 100 000 cycles for a fatigue test of 2 000 000 cycles.

At least 24 hours after the 2 000 000 cycles, the static and dynamic stiffness tests shall be carried out in accordance with [5.2.5.1](#) at a room temperature of  $(23 \pm 5)$  °C. The sleeper shall be kept at room temperature for at least 24 hours before the stiffness tests.

After the fatigue test, the strength test at the rail seat shall be carried out in accordance with [5.2.5.3](#). The test load is increased until  $k_3 \cdot F_{r0}$  is reached. If  $d_{2s,lim}$  is reached before, the test may be stopped.

The report shall include the following elements:

- a graph showing the displacement of the actuator as a function of the load,  $F_r$ , during the 2 000 000 cycles;
- the stiffness results;
- the variation of static and dynamic stiffness ( $\Delta k_r$ ) before and after the fatigue test; and
- the results of the strength test at the rail seat.

### 5.2.5.3 Strength at the rail seat

The strength test at the rail seat section for the design approval test is performed by applying a load at the rail seat and by measuring the deformations of the sleeper, bearer or transom.

The test arrangement is shown in [5.2.1.1](#).

The load factors  $k_{1s}$  and  $k_{2s}$  shall be defined for the exceptional and the accidental test load levels, and the upper limit values  $d_{1s,lim}$  and  $d_{2s,lim}$  shall be defined for the deformations related to the exceptional and the accidental load levels.

The test load is increased until  $(k_{2s} \cdot F_{r0})$  is reached. If  $d_{2s,lim}$  is reached before, the test may be stopped. The load shall be applied with a speed of between 60 and 120 kN/min.

The test report shall include the following deformation:  $d_{0s}$  at load level  $F_{r0}$ ,  $d_{1s}$  at load level  $(k_{1s} \cdot F_{r0})$ , and  $d_{2s}$  at load level  $(k_{2s} \cdot F_{r0})$  if the test load has been increased up to this level. The test report shall also include the vertical loads related to deformations  $d_{1s,lim}$  and  $d_{2s,lim}$  if the test has been stopped at this deformation.

## 5.3 Tests with geometric ballast plate (GBP) or with flat plate (FP) at rail seat

### 5.3.1 Stiffness with GBP or with FP at rail seat

The static and low frequency dynamic vertical stiffness (and bedding modulus) of a polymeric composite sleeper or bearer with GBP may be measured in accordance with [Annex A](#) and [Annex B](#).

The static and low frequency dynamic vertical stiffness (and bedding modulus) of a polymeric composite sleeper or bearer with FP may be measured in accordance with [Annex C](#).

The low frequency dynamic stiffness (and bedding modulus) is measured at  $(5 \pm 1)$  Hz (and optional frequency tests at  $[10 \pm 1]$  Hz,  $[20 \pm 2]$  Hz and  $[30 \pm 3]$  Hz).

### 5.3.2 Compression test with GBP or with FP at rail seat

The compression test at the rail seat section for the design approval test is performed by applying a load at the rail seat and by measuring the deformation of the sleeper, bearer or transom.

The test arrangement is shown in [Annex B, Figure B.1](#).

Load factors  $k_{1s}$  and  $k_{2s}$  shall be defined for the exceptional and the accidental test load levels related to the exceptional and the accidental load level.

The test load is increased until  $k_{2s} \cdot F_{r0}$  is reached. The load shall be applied with a speed of between 60 and 120 kN/min.

The test report shall include the following deformations:  $d_{0c}$  at load level  $F_{r0}$ ,  $d_{1c}$  at load level ( $k_{1s} \cdot F_{r0}$ ), and  $d_{2c}$  at load level  $k_{2s} \cdot F_{r0}$ .

## 5.4 Thermal expansion

### 5.4.1 Principle

The objective of this test is to define the linear thermal expansion coefficient of the sleeper, bearer or transom.

### 5.4.2 Apparatus

#### 5.4.2.1 Climatic chamber

A section of sleeper, bearer or transom (see 5.4.2.2) shall be placed in a climatic chamber and the temperatures shall be varied between  $-20\text{ °C}$  and  $40\text{ °C}$  with forced air circulation.

The climatic chamber shall be calibrated to an accuracy of  $\pm 3\text{ °C}$  for the temperature of  $-20\text{ °C}$  and the temperature of  $40\text{ °C}$ .

#### 5.4.2.2 Thermal sensor

The temperature in the climatic chamber is measured with an independent thermal sensor to an accuracy of  $\pm 0,2\text{ °C}$ .

#### 5.4.2.3 Test specimen

Dimensions of the test specimen: an element of sleeper, bearer or transom at  $(800 \pm 50)$  mm in length with the full cross section of the sleeper, bearer or transom. The sleeper, bearer or transom is to be cut in such a way as to conserve the symmetry of the complete sleeper, bearer or transom (central part of the sleeper or bearer).

Reference points shall be placed on the sleeper, bearer or transom at  $(500 \pm 10)$  mm centred on the sample, on the top and on the bottom of the sample.

#### 5.4.2.4 Instruments for the control of dimensions

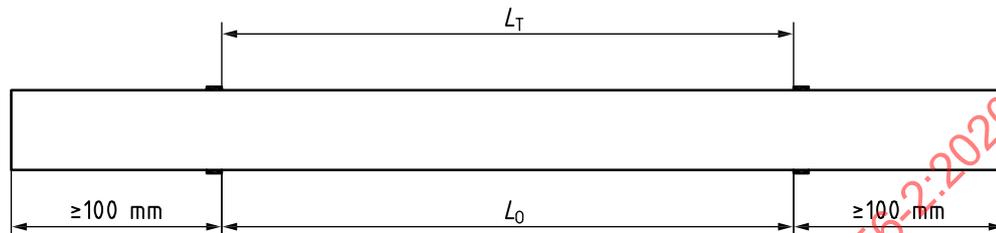
The instruments used shall be capable of measuring the length of the test object according to the controlled dimensions:

- within  $\pm 0,20$  mm for a theoretically linear thermal expansion coefficient of at least  $120 \cdot 10^{-6}\text{ K}^{-1}$ ;
- within  $\pm 0,10$  mm for a theoretically linear thermal expansion coefficient of between 60 and  $120 \cdot 10^{-6}\text{ K}^{-1}$ ;
- within  $\pm 0,05$  mm for a theoretically linear thermal expansion coefficient between 30 and  $60 \cdot 10^{-6}\text{ K}^{-1}$ ;
- within  $\pm 0,02$  mm for a theoretically linear thermal expansion coefficient of between 12 and  $30 \cdot 10^{-6}\text{ K}^{-1}$ ; and
- within  $\pm 0,01$  mm for a theoretically linear thermal expansion coefficient of between 6 and  $12 \cdot 10^{-6}\text{ K}^{-1}$ .

### 5.4.3 Procedure

Step 1: The test specimen is placed in the climatic chamber at  $(-20 \pm 3)^\circ\text{C}$  on a surface allowing the free movement of the sample for 24 hours. During this 24-hour period, the temperature is measured. The average temperature over the last of the 24 hours is written  $T_1$ .

Step 2: After the 24 hours, the lengths of test specimen  $L_{T1}$  and  $L_{O1}$  (see [Figure 13](#)) are measured at temperature  $T_1$ .



#### Key

$L_0$  length measured on the opposite side of top of sleeper, bearer or transom

$L_T$  length measured on the top of the sleeper, bearer or transom

**Figure 13 — Points of measurement on element of sleeper, bearer or transom**

Step 3: The temperature of the climatic chamber increases up to temperature  $(T_1 + 60)^\circ\text{C}$ . The temperature  $(T_1 + 60)^\circ\text{C}$  is maintained for 24 hours and the test object is placed on a surface allowing for the free movement of the sample. The temperature is measured throughout the 24 hours. The average temperature over the last hour is written  $T_2$ .

Step 4: After 24 hours, the lengths of test specimen  $L_{T2}$  and  $L_{O2}$  (see [Figure 13](#)) are measured for temperature  $T_2$ .

Step 5: The temperature of the climatic chamber decreases to  $(-20 \pm 3)^\circ\text{C}$ . The temperature  $(-20 \pm 3)^\circ\text{C}$  is maintained for 24 hours and the test object is placed on a surface allowing the free movement of the sample. The temperature is measured throughout the 24 hours. The average temperature over the last hour is written  $T_3$ .

Step 6: After the 24 hours, the lengths of test specimen  $L_{T3}$  and  $L_{O3}$  (see [Figure 13](#)) are measured at temperature  $T_3$ .

Step 7: The temperature of the climatic chamber increases up to  $(T_3 + 60)^\circ\text{C}$ . The temperature  $(T_3 + 60)^\circ\text{C}$  is maintained for 24 hours and the test object is placed on a surface allowing the free movement of the sample. The temperature is measured throughout the 24 hours. The average temperature over the last hour is written  $T_4$ .

Step 8: After 24 hours, the lengths of test specimen  $L_{T4}$  and  $L_{O4}$  (see [Figure 13](#)) are measured at temperature  $T_4$ .

Calculate the linear thermal expansion coefficient  $\alpha_T$  as per [Formula \(21\)](#):

$$\alpha_{T,\text{top}} = \frac{1}{2} \cdot \left( \frac{L_{T2} - L_{T1}}{L_{T1} \cdot (T_2 - T_1)} + \frac{L_{T4} - L_{T3}}{L_{T3} \cdot (T_4 - T_3)} \right) \text{ in } K^{-1} \quad (21)$$

The report shall include the following elements:

- all the lengths measured ( $L_{T1}$ ,  $L_{T2}$ ,  $L_{T3}$ ,  $L_{T4}$ ,  $L_{O1}$ ,  $L_{O2}$ ,  $L_{O3}$  and  $L_{O4}$ );
- all the temperatures measured ( $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$ );
- the temperature curves;

- the photos of the test equipment;
- the linear thermal expansion coefficient  $\alpha_{T,top}$  and  $\alpha_{T,bottom}$ .

## 5.5 Interface between the rail and the sleeper

### 5.5.1 Permanent deformation of screw/insert as a function of temperature

#### 5.5.1.1 General

This test is applied to the fastening system elements that are embedded or fixed into the sleeper, bearer or transom.

For inserts designed to take rail spikes or screw spikes, the load shall be applied via a nominal-depth screwed rail spike or lag bolts. For elements such as direct fastenings or baseplates moulded in the sleeper or dowel, the load shall be applied via the fastening system.

#### 5.5.1.2 Apparatus

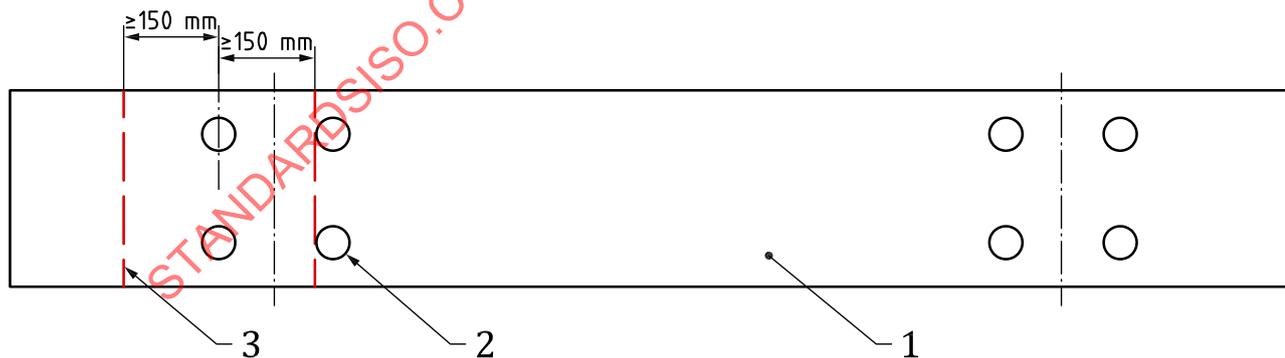
##### 5.5.1.2.1 Climatic chamber

The climatic chamber shall accept a sleeper, bearer or transom segment length of 300 mm and be capable of temperature adjustment between  $-30\text{ }^{\circ}\text{C}$  and  $60\text{ }^{\circ}\text{C}$ .

The climatic chamber shall be calibrated to an accuracy of  $\pm 3\text{ }^{\circ}\text{C}$  for the temperatures  $-25\text{ }^{\circ}\text{C}$  and  $52\text{ }^{\circ}\text{C}$ .

##### 5.5.1.2.2 Element of sleeper

The test is performed on a first-level fastening element within a sleeper, bearer or transom segment (for example, inserts, dowels in the sleepers) of at least 300 mm in length (for positioning of the screw, dowel or insert, see [Figure 14](#)). The fastening element is tensioned by spring washers at 60 kN divided by the number of fastening points or rail fastening system inserts. The set of spring washers shall be calibrated by the laboratory with the appropriated procedure. Dimension "u" is measured over three points spaced at regular intervals around the washer circumference after the load has been applied by the spring washers (see [Figure 15](#)).



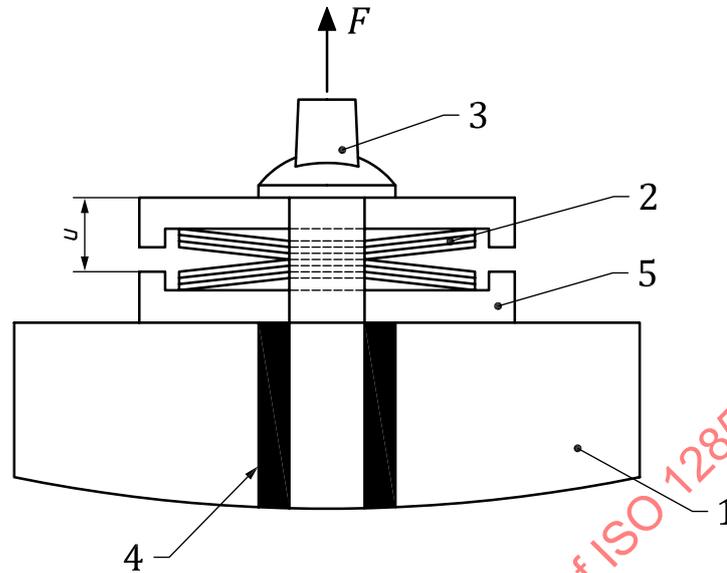
#### Key

- 1 polymeric composite sleeper, bearer or transom
- 2 position of screw, dowel or insert depending on the fastening system
- 3 position of the cut

**Figure 14 — Example of segment of sleeper, bearer or transom**

The stiffness of the spring washer assembly, measured during the pre-calibration, shall be communicated in the report. The spring washer assembly shall have a stiffness of between 10 and 25 kN/mm.

For example, for a rail fastening system held in place by four rail screws, the vertical load,  $F$ , applied on a selected screw is 15 kN.



#### Key

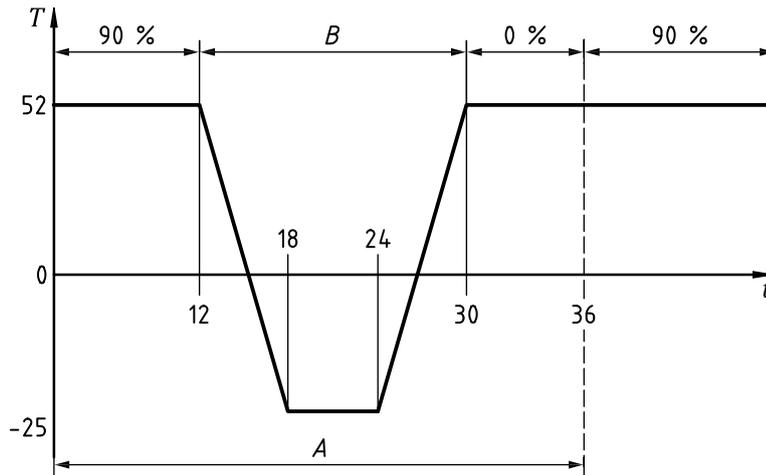
- 1 sleeper segment, including baseplate (if used)
- 2 spring washers
- 3 screw under test
- 4 insert or dowel (if present);
- 5 steel cup with minimum thickness of 5 mm:  $\varnothing 80$  mm for direct fastening in contact the polymeric composite sample or  $\varnothing 110$  mm for fastening with baseplate in contact the polymeric composite sample
- $u$  dimension  $u$
- $F$  vertical load

**Figure 15 — Example of cyclic test – test rig (mounted with insert and screw)**

#### 5.5.1.3 Procedure

The test arrangement shall be set up in a ventilated and thermal-controlled chamber and put through seven temperature-humidity cycles, as defined in [Figure 16](#).

NOTE The 52 °C test temperature has been defined based on temperature measurements at the surface of sample polymer materials exposed to solar radiation.



**Key**

- $t$  time in hours
- $T$  chamber temperature in degrees Celsius
- A test cycle
- % relative humidity in the chamber
- B no relative humidity requirement between 12 and 30 hours

**Figure 16 — Creep test - Test cycles**

On completion of the test, creep shall be measured at least 24 h after the 7 climatic cycles. The creep value is defined as the increase of the mean value of the "u" dimension determined at the three measurement points spaced at regular intervals around the cup circumference.

The report shall include the following items:

- the variation of dimension "u" measured at three points;
- the creep value (the mean variation in the "u" dimension);
- the result of the check for cracking around the fastening element using a micrometer accurate enough to detect a 0,01 mm crack before and after the test.

**5.5.2 Fastening system**

Fastening system design approval tests, if required, shall take into account relevant national or regional standards.

The fastening test method for effect of repeated loading shall be carried out in conjunction with the polymeric composite sleeper, bearer or transom.

For Europe, design approval tests can be defined by the purchaser according to EN 13481-3 or EN 13481-7 or EN 13481-5. For Japan, design approval tests can be defined by the purchaser according to [20]. For China, design approval tests can be defined by the purchaser according to [21] or [22].

Upon completion of the fastening system fatigue test according to EN 13146-4, the sleeper, bearer or transom material surrounding the fastening system should not show signs of damage (no significant cracking, deformation or permanent sag of the rail seat section). Furthermore, the variation of position of the baseplate on the sleeper, bearer or transom should be measured and documented.

### 5.5.3 Electrical resistance

Electrical resistance design approval tests, if required, shall be carried out taking into account relevant national or regional standards.

For Europe, if the user requires the fastening system to provide electrical insulation this should be not less than 5 k $\Omega$  when measured in accordance with EN 13146-5.

For Japan, design approval tests can be defined by the purchaser according to [20]. The user may specify a higher value for use with certain track circuits. For China, design approval tests can be defined by the purchaser according to TB/T 3396.5. The user may specify a higher value for use with certain track circuits.

### 5.5.4 Screw, spike, cast-in and glued-in fastening components

Proof load test for pull-out design approval tests, if required, shall be carried out taking into account relevant national or regional standards.

For Europe, a vertical load test should be performed using the procedure described in EN 13146-10. Three sleepers (bearers or transoms) should be selected for the test and one cast-in or glued-in component in each sleeper, bearer or transom shall be subjected to the test. The proof load applied in each test shall be 30 kN for a fastening system with baseplate and with 4 screws and 60 kN for 2 anchorages per system – direct fastening system. Following the test there shall be no evidence of damage to the fastening component or the sleeper, bearer or transom or supporting element that could result in a loss of integrity or durability of the system. For Japan, design approval tests can be defined by the purchaser according to [20]. For China, design approval tests can be defined by the purchaser according to TB/T 3396.7.

## 5.6 Fire

Sleepers, bearers and transoms exposed to fire (for example, installed in tunnels) shall be treated as flooring material separated from each other by mineral content (ballast or concrete). As such, fire performance and test arrangements shall be specified by the purchaser and tested in order to evaluate the ignitability of the sleepers, bearers and transoms, the toxicity, the opacity of the smoke and the propagation of fire in track.

NOTE See the following standards for the conception of the test arrangement: ISO 11925-2, ISO 5659-2 and ISO 21367.

## 5.7 System Test

If acceptable displacement is exceeded during the fatigue tests, the polymeric composite sleeper and bearer may be tested in a ballast box in accordance with [Annex D](#). The test load  $F_{\text{ballast}}$  shall be defined by the purchaser.

$F_{\text{ballast}} = 2 P_k$  should be used for one sleeper (see ISO 12856-3).

**Annex A**  
(informative)

**Geometric ballast plate (GBP)**

**A.1 Design of the GBP**

The design of the GBP should be in accordance with [Figures B.1](#) and [B.2](#).

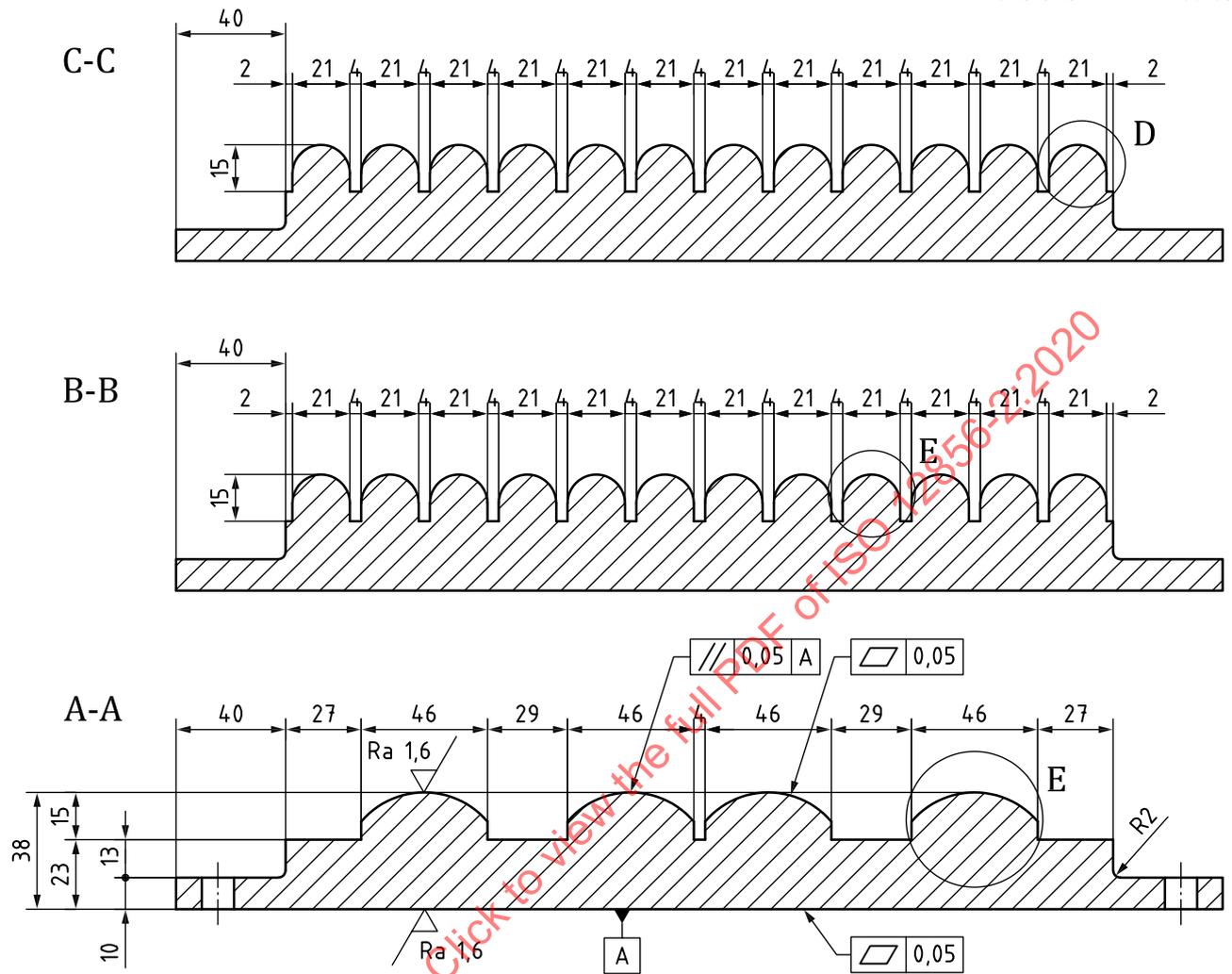
The general tolerances are given in ISO 2768 (all parts).

**A.2 Material of GBP**

The steel material is 1.4301, as defined in the EN 10027 series.

STANDARDSISO.COM : Click to view the full PDF of ISO 12856-2:2020

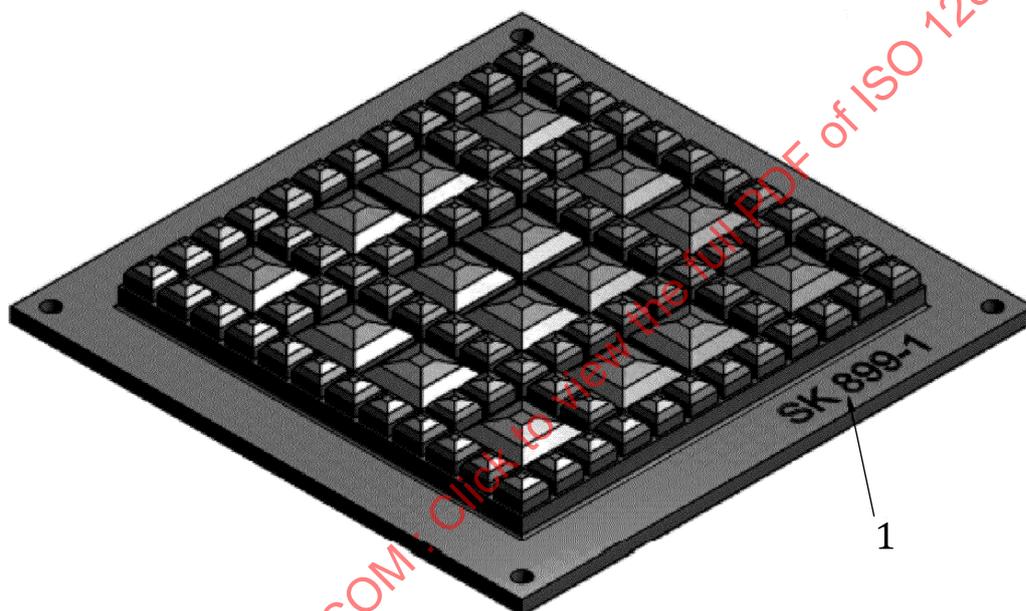
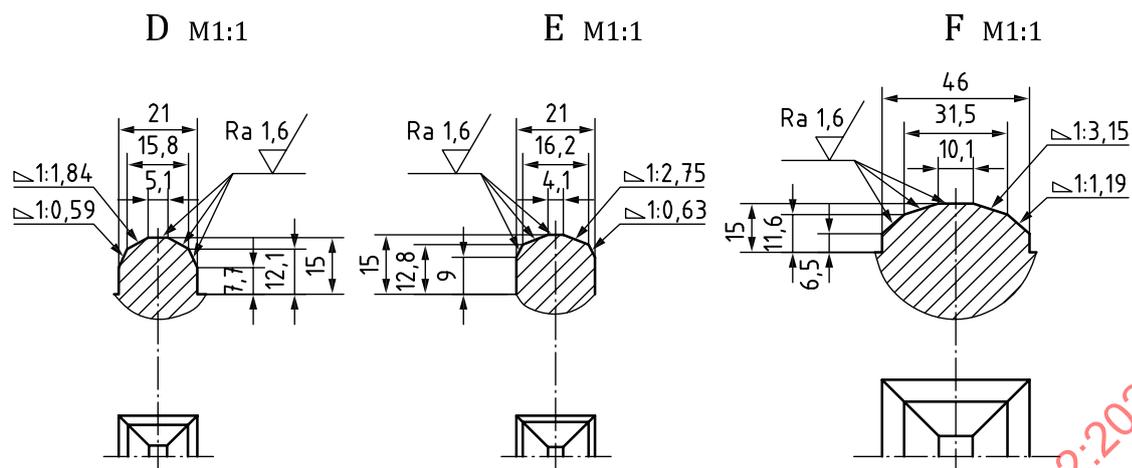
Dimensions in millimetres



**Key**

- A-A section of the inner big pyramids
- B-B section of the inner small pyramids between the inner big pyramids
- C-C section of the outer small pyramids

**Figure A.1 — Drawing of GBP**



**Key**

- D detail of the outer small pyramids
- E detail of the inner small pyramids between the inner big pyramids
- F detail of the inner big pyramids
- 1 original reference of GBP drawing (SK 899 – sequential number)

**Figure A.2 — Technical drawing and representation of GBP**

## Annex B (informative)

### Test procedures for stiffness measurement of polymeric composite sleeper or bearer with GBP

#### B.1 General

This test measures the stiffness and bedding modulus of polymeric composite sleepers or bearers with GBP.

NOTE The result of this test is used to calculate the rail seat load. See ISO 12856-1.

#### B.2 Static test procedure

##### B.2.1 Principle

A force is applied in a normal manner to the test polymeric composite sleeper or bearer and the displacement is measured.

##### B.2.2 Apparatus

**B.2.2.1 Controlled temperature test area**, in which the area of the laboratory where the test is conducted should be maintained at  $(23 \pm 5)^\circ\text{C}$ .

##### B.2.2.2 GBP

The GBP (see [Annex A](#) for details) is connected with the actuator and therefore the effect of weight is included in force  $F$ .

For the stiffness test with sleeper, part of the surface of GBP is used. This surface A is the projected surface between the polymeric composite sleeper and the GBP for measurement of the bedding modulus. Surface A shall be measured.

##### B.2.2.3 Articulated support

See [Figure B.1](#).

##### B.2.2.4 Slope taking-up wedge

See [Figure B.1](#).

**B.2.2.5 Actuator**, capable of applying a pressure of  $0,5 \times Q_{\text{nom}}$ .

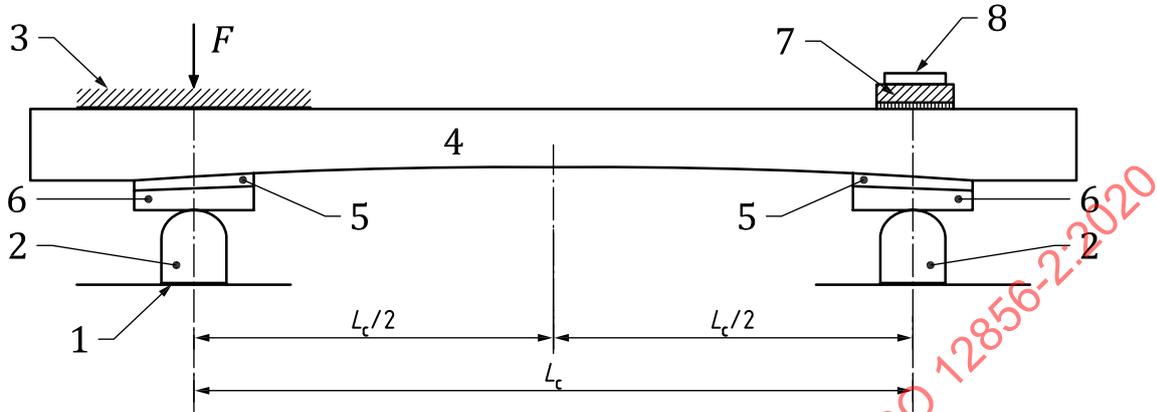
##### B.2.2.6 Displacement measuring instruments

Instruments conforming to ISO 9513:2012/Cor 1:2013, Table 2, class 1 shall be used. When non-contact instruments are used, they shall be calibrated to ensure the accuracy of measurement meets the following requirements.

The instruments shall be capable of measuring the vertical displacement within  $\pm 0,01$  mm.

**B.2.2.7 Force measuring instruments**, conforming to ISO 7500-1, class 2 over the required range of force.

**B.2.2.8 Recording equipment**, to make a digital recording and printout of the displacement and applied force.



**Key**

- 1 rigid support
- 2 articulated support and steel plate (minimum length: bottom width of the sleeper at the rail seat +20 mm, width:  $140 \pm 1$  mm, thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240)
- 3 GBP (geometric ballast plate) (see Annex A for details) fixed to actuator in contact with the sleeper or bearer
- 4 polymeric composite sleeper or bearer with baseplates (if the baseplate is used)
- 5 standard rail pad as defined by the purchaser
- 6 steel tapered packing compensating the inclination of the rail seat (minimum length: length of the standard rail pad +20 mm, width:  $140 \pm 1$  mm (this width can be reduced in line with the real width of the rail foot used in track), thickness: minimum 12 mm and minimum hardness Brinell: HBW > 240) if necessary
- 7 resilient pad (minimum length: bottom width of the sleeper at the rail seat + 20 mm, width:  $140^{+10}_0$  mm, thickness:  $15^{+2}_3$  mm and static bedding modulus: static secant bedding modulus measured between 0,3 MPa and 2 MPa:  $1 \leq C \leq 4$  N/mm<sup>3</sup>)
- 8 bar fixing maintained by two threaded rods M24 with nuts tightened between 10 Nm and 15 Nm
- $L_c$  design distance between centre lines of the rail seat

NOTE An example of articulated support is shown in the EN 13230-2:2016, Annex A or in JIS E 1203.

**Figure B.1 — Test setup and loading**

**B.2.3 Procedure**

The flatness of the test area (cross width) is controlled with a straight ruler of 300 mm (minimum length). The maximum deviation shall be less than 0,2 mm in order to accept the sleeper head for stiffness test.

All components (polymeric composite sleeper or bearer, GBP, rail pad, slope taking-up wedge and articulated support) shall be at a temperature of  $(23 \pm 5)$  °C prior to starting the test. Place the test set-up in the following sequence: flat rigid horizontal base, articulated support, slope taking-up wedge, standard rail pad defined by the customer, polymeric composite sleeper or bearer, GBP fixed to actuator (where the centre of the plate coincides with the theoretical crossing point between the sleeper centre line and the rail centre line with a tolerance of position  $\pm 3$  mm) as shown in Figure B.1.

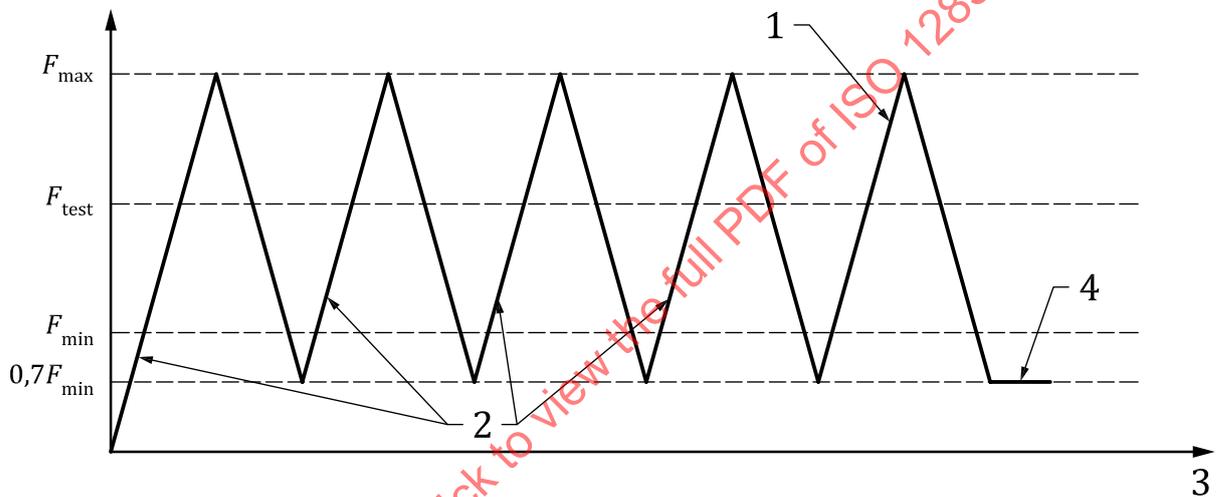
Locate four independent instruments to measure the displacement between the GBP and the top of the sleeper or baseplate. The other extremity of the sleeper is maintained as shown in Figure B.1. If the

displacement measured by any of the instruments differs from the average displacement by  $\geq 20\%$  of the maximum displacement, repeat the loading cycle ensuring that the force is applied centrally to the pad.

**Table B.1 — Load for static and low frequency dynamic stiffness and bedding modulus**

| $F_{\min}$<br>kN             | $F_{\text{test}}$<br>kN                                     | $F_{\max}$<br>kN           |
|------------------------------|-------------------------------------------------------------|----------------------------|
| $0,1 \times F_{\text{test}}$ | $\frac{0,3 \times 0,4 \times Q_{\text{nom}}}{2 \times L_p}$ | $2 \times F_{\text{test}}$ |

Apply a force,  $F_{\max}$ , through a spherical seating in the actuator (where the centre of GBP coincides with the axis of load), as specified in [Table B.1](#). Then reduce the force to  $0,7 F_{\min}$  as specified in [Table B.1](#) and repeat this cycle of loading and unloading three more times with a rate of pressure application of  $0,01 \pm 0,001 \text{ N/mm}^2\text{s}$ . Maintain the applied force ( $0,7 F_{\min}$ ), then record the displacement whilst increasing the applied force to  $F_{\max}$  (see [Figure B.2](#)).



**Key**

- $t$  time
- a Fifth loading: temporal laps to record the displacement whilst increasing the applied force to  $F_{\max}$ .
- b Four first loadings: preconditioning.
- c If a dynamic stiffness is measured after the static stiffness test, the force is maintained at  $0,7 F_{\min}$ .

**Figure B.2 — Loading cycle of stiffness measurement**

Calculate the static stiffness and static bedding modulus of loading cycles using [Formulae \(B.1\)](#) and [\(B.2\)](#):

$$k_{\text{stat}} = \frac{F_{\text{test}} - F_{\min}}{d_{\text{test}} - d_{\min}} \text{ (of fifth loading cycle)} \tag{B.1}$$

$$C_{\text{stat}} = \frac{F_{\text{test}} - F_{\min}}{(d_{\text{test}} - d_{\min}) \cdot A} \text{ (of fifth loading cycle)} \tag{B.2}$$

where

- $d_{\min}$  is the average displacement of all sensors when the applied force is increased from  $F_{\min}$ ;
- $d_{\text{test}}$  is the average displacement of all sensors when the applied force is increased from  $F_{\text{test}}$ ;
- $A$  is the projected area between the polymeric composite sleeper or bearer and the GBP.

$$k_{\max} = \frac{F_{\max} - F_{\min}}{d_{\max} - d_{\min}} \quad (\text{of fifth loading cycle}) \quad (\text{B.3})$$

$$C_{\max} = \frac{F_{\max} - F_{\min}}{(d_{\max} - d_{\min}) \times A} \quad (\text{of fifth loading cycle}) \quad (\text{B.4})$$

where  $d_{\max}$  is the average displacement of all sensors when the applied force is increased from  $F_{\max}$ .

#### B.2.4 Test report

The test report shall include at least the following information:

- a) reference to this document, i.e. ISO 12856-2;
- b) name and address of the laboratory performing the test;
- c) date of test performed;
- d) name, designation and description of the test specimens;
- e) origin of the test specimens;
- f) load deflection curve (if requested by purchaser);
- g) value of  $A$ ;
- h) values of  $F_{\min}$ ,  $F_{\max}$ ,  $F_{\text{test}}$ ,  $d_{\min}$  and  $d_{\text{test}}$ ;
- i) static stiffness of each polymeric composite sleeper or bearer tested;
- j) static bedding modulus of each polymeric composite sleeper or bearer tested;
- k) planarity of polymeric composite sleeper or bearer in contact with GBP;
- l) any deviations from the test procedures;
- m) any unusual features observed.

### B.3 Low frequency dynamic test procedure

#### B.3.1 Principle

This method is valid for one frequency in the range (2 – 30) Hz.

A cyclic force is applied, normal to the test pad of the sleeper, through an actuator at a single specified frequency or, if a general value of low frequency dynamic stiffness is required, at three constant frequencies. The resulting maximum and minimum displacements of the surface of the pad are measured at the maximum and minimum forces.

#### B.3.2 Apparatus

##### B.3.2.1 General

The following equipment used for the static test is also used in this test:

- a) controlled temperature test area (see [B.2.2.1](#));
- b) GBP (geometric ballast plate) (see [B.2.2.2](#));
- c) articulated support (see [B.2.2.3](#)) and slope taking-up wedge (see [B.2.2.4](#)).