SLOVENSKI STANDARD
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Železniške naprave - Zgornji ustroj proge - Betonski pragi in kretniški betonski pragi - 6. del: Načrtovanje

Railway applications - Track - Concrete sleepers and bearers - Part 6: Design

Bahnanwendungen - Oberbau - Gleis- und Weichenschwellen aus Beton - Teil 6: Entwurf

Applications ferroviaires - Voie - Traverses et supports en béton - Partie 6 : Conception

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ICS:

45.080	Tračnice in železniški deli	Rails and railway components
91.100.30	Beton in betonski izdelki	Concrete and concrete products

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Railway applications - Track - Concrete sleepers and bearers - Part 6: Design

Applications ferroviaires - Voie - Traverses et supports en béton - Partie 6 : Conception

Bahnanwendungen - Oberbau - Gleis- und Weichenschwellen aus Beton - Teil 6: Bemessung

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 13230-6:2020) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2020, and conflicting national standards shall be withdrawn at the latest by October 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

This European Standard is one of the EN 13230 series, *Railway applications – Track – Concrete sleepers and bearers*, which consist of the following parts:

— *Part 1: General requirements*;

— *Part 2: Prestressed monoblock sleepers*;

— *Part 3: Twin-block reinforced sleepers*;

— *Part 4: Prestressed bearers for switches and crossings*;

— *Part 5: Special elements*;

— *Part 6: Design*.

This European Standard can be used as a technical basis between contracting parties (purchaser – supplier).

Annexes A and B are informative; they can be used as normative requirements by completion of a contract, if agreed by the contracting parties.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document covers the design of concrete sleepers and bearers and is used in conjunction with the following parts:

- *Part 1: General requirements*;
- *Part 2: Prestressed monoblock sleepers*;
- *Part 3: Twin-block reinforced sleepers*;
- *Part 4: Prestressed bearers for switches and crossings*;
- *Part 5: Special elements*.

Concrete sleepers and bearers are safety critical components for railway applications. They are not covered by any other European Standard.

As safety critical components, an agreement is needed between purchaser and supplier to operate a factory Quality System.

1 Scope

This document provides particular design guidance in the following areas:

— derivation of characteristic loads and test loads;

— calculation of characteristic and test bending moments.

The aim of this document is to give guidance for the preparation of all data to be given by the purchaser to the supplier in accordance with Parts 1 to 5 of EN 13230. It applies to gauges 1 000 mm, 1 435 mm, 1 668 mm as well as to all lengths of sleepers and bearers.

This document gives special criteria for the design of concrete sleepers and bearers as track components. The design methods in the Eurocode do not apply to these concrete elements.

All track parameters to be taken into account for the design of sleepers and bearers are detailed in this document. Information is given on these parameters so that they can be used as inputs for the design calculation process. It is the responsibility of the purchaser to calculate or determine all track parameters used in this document.

This document gives guidance for the design calculation process. It explains how experience and calculation can be combined to use design parameters.

This document gives examples of numerical data that can be used when applying Clauses 4 to 6 according to the state of the art.

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.

EN 13146-3, *Railway applications – Track – Test methods for fastening systems – Part 3: Determination of attenuation of impact loads*

EN 13146-5, *Railway applications – Track – Test methods for fastening systems – Part 5: Determination of electrical resistance*

EN 13146-10, *Railway applications – Track – Test methods for fastening systems – Part 10: Proof load test for pull-out resistance*

EN 13230-1:2016, *Railway applications – Track – Concrete sleepers and bearers – Part 1: General requirements*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in EN 13230-1:2016 and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
nominal axle load
A_{nom}
axle load from nominal weight of rolling stock

3.2
nominal wheel load
Q_{nom}
static vertical wheel load resulting from nominal axle load

3.3
characteristic wheel load
Q_k
characteristic value of the vertical wheel load

3.4
factor k_p
factor used for rail pad attenuation

3.5
factor k_v
factor used for the effect of speed

3.6
factor k_d
factor used for longitudinal distribution of vertical load between sleepers

3.7
factor k_r
factor used for variations of the longitudinal load distribution between sleepers due to support faults

3.8
factor $k_{i,r}$
factor used for calculation of characteristic bending moments at rail seat due to irregularities in the support along the length of the sleeper

3.9
factor $k_{i,c}$
factor used for calculation of characteristic bending moments at centre section due to irregularities in the support along the length of the sleeper

3.10
internal lever arm
λ
internal lever arm of the forces and ballast reaction acting on the sleeper at the rail seat section

3.11
exceptional load
load that occurs only a few times in the life of sleeper

3.12
accidental load
load that occurs only once in the life of a sleeper

3.13
factor k_t
factor used for the calculation of acceptance criteria for first crack formation in static tests

3.14
dynamic rail seat load
P_k
characteristic load on a rail seat of the sleeper for normal service dynamic loading

3.15
characteristic bending moment
M_k
bending moment from dynamic rail seat load P_k

3.16
characteristic positive bending moment for rail seat section
$M_{k,r,pos}$
positive bending moment at rail seat from dynamic rail seat load P_k

3.17
characteristic negative bending moment for rail seat section
$M_{k,r,neg}$
negative bending moment at rail seat from dynamic rail seat load P_k

3.18
characteristic negative bending moment for centre section
$M_{k,c,neg}$
negative bending moment at centre section from dynamic rail seat load P_k

3.19
characteristic positive bending moment for centre section
$M_{k,c,pos}$
positive bending moment at centre section from dynamic rail seat load P_k

3.20
test bending moment
M_t
test bending moment for first crack formation derived from characteristic bending moment

3.21
positive test bending moment for rail seat section
$M_{t,r,pos}$
positive test bending moment for first crack formation at rail seat derived from the characteristic bending moment

3.22
negative test bending moment for rail seat section
$M_{t,r,neg}$
negative test bending moment for first crack formation at rail seat derived from the characteristic bending moment

3.23
negative test bending moment for centre section
$M_{t,c,neg}$
negative test bending moment for first crack formation at centre section derived from the characteristic bending moment

3.24
positive test bending moment for centre section
$M_{t,c,pos}$
positive test bending moment for first crack formation at centre section derived from the characteristic bending moment

3.25
factor k_1
factor used for calculation of test bending moments which is due to exceptional and random impact load, which is applied to characteristic bending moments and which is k_{1d} for dynamic test and k_{1s} for static test

3.26
factor k_2
factor which is used for calculation of test bending moments due to accidental impact load, which is applied to characteristic bending moments and which is k_{2d} for dynamic test and k_{2s} for static test

3.27
factor k_3
factor which is used for calculation of fatigue test bending moments and which is applied to characteristic bending moments

4 General requirements

4.1 General process for determination of bending moments

4.1.1 General

The track is an assembly of transverse concrete sleepers or bearers secured to the rails by means of a fastening system and supported by ballast or other support. It is characterized by the gauge of the track, the rail profile, the inclination of the rails and the spacing of the concrete sleepers and bearers. The assembly including the rail, the fastening system and concrete sleepers or bearers on ballast or other support may be considered as a beam on an elastic foundation.

The determination of bending moments in sleepers and bearers laid on ballast for the service conditions may be obtained using the three following different approaches.

4.1.2 Empirical method

In the empirical method appropriate sleepers or bearers are tested in track under service conditions. Deficiency from tested sleepers/bearers can lead to step wise improvement of the sleeper/bearer design. The results shall be confirmed by permanent observation during at least five years. The characteristic bending moments shall be determined by measurements in track. The number of the test samples shall be sufficient to give statistically reliable results.

The characteristic bending moment may also be determined by means of bending tests according to the EN 13230 series using sleepers that have been in service for five years at least. The test bending moment that produces the first crack formation shall be in accordance with EN 13230-1:2016, 7.2.

Figure 1 details steps for the determination of characteristic bending moments for prestressed concrete sleepers. In this figure, new sleeper means a sleeper with geometry similar to the existing one.

For twin block concrete sleepers and bearers the same methodology shall be used.

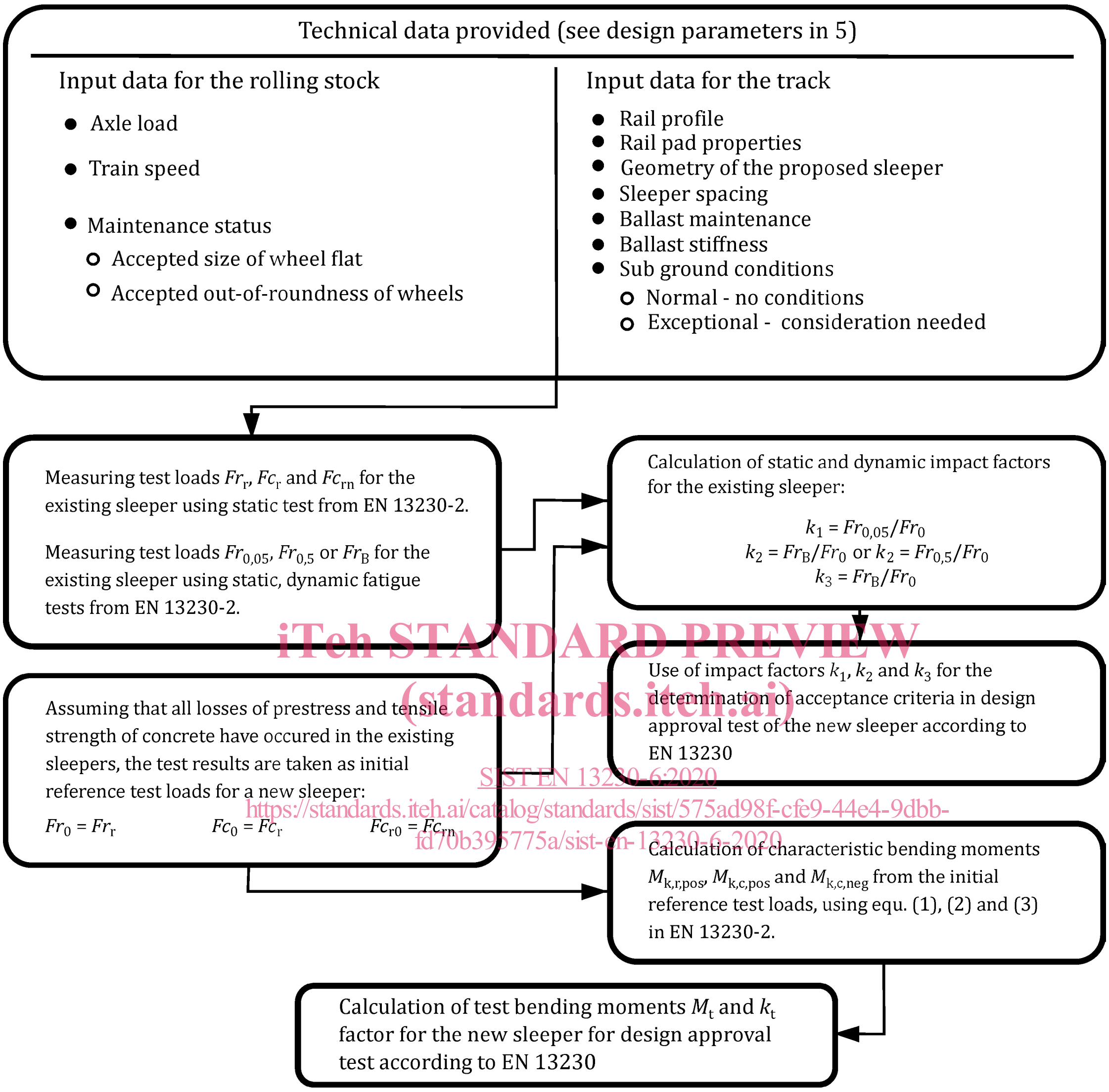

Figure 1 — Empirical method for design of prestressed concrete sleepers

NOTE Taking the test loads Fr_r, Fc_r and Fc_{rn} of the existing sleeper as initial reference test loads for a new sleeper normally will lead to characteristic bending moments lying on the safe side. The assumption that all losses of prestress and strength have taken place may be correct for an exposition to traffic loads for at least 5 years.

In order to get more information about the load carrying capacity of the existing sleeper, additional tests for inverse bending moments at the rail seat and dynamic tests at sleeper centre may be carried out.

4.1.3 Theoretical method

The theoretical method shall be based on design procedures considering the dynamic load, the elastic behaviour of all track components including all types of elastic pads, the variable ballast-subsoil elasticity and the different ballast consolidation phases.

Figure 2 details steps for the determination of bending moments for prestressed concrete sleepers. For twin block concrete sleepers and bearers the same methodology shall be used.

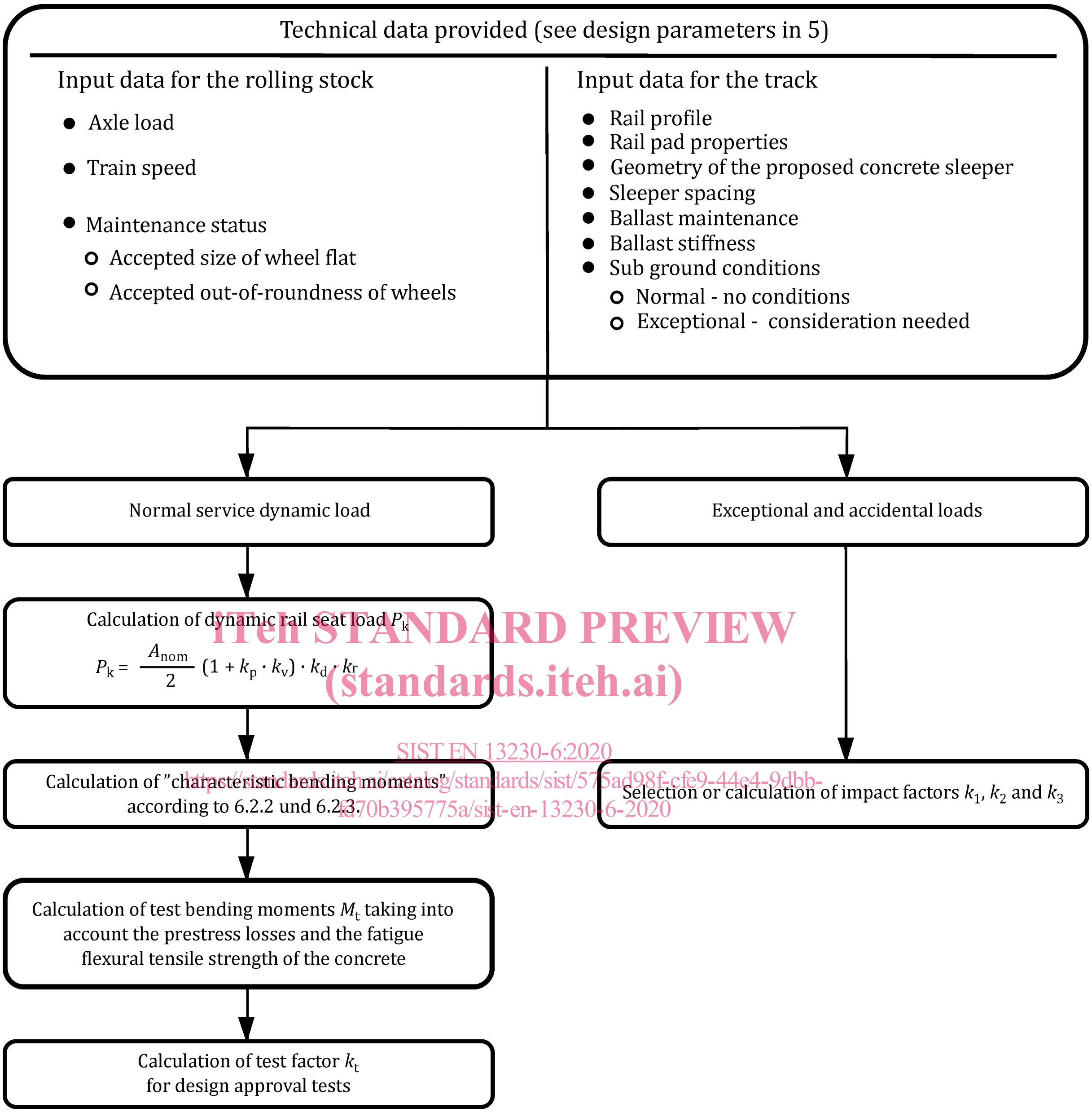

Figure 2 — Theoretical method for design of prestressed concrete sleepers

4.1.4 Combined method

The combined method includes empirical and theoretical elements leading to a shorter product development time.

4.2 Crack formation in concrete sleepers or bearers

4.2.1 Cracks under rail seat

Wheel loads generate positive and negative bending moments under the rail seat.

The bending resistance at the end of the required service life time under the rail seat is determined by the characteristic bending moment.

When subjected to the static test bending moment, there shall be no first crack at the tensile face of the prestressed concrete sleeper or bearer, see EN 13230-1:2016, 7.2.

The second stage of the test bending moment to be defined is the bending moment due to exceptional and random impact loads. It is calculated by multiplying the positive characteristic bending moment $M_{k,r,pos}$ by coefficient k_1. Any crack produced by this bending moment shall close (crack width below 0,05 mm) upon removal of the bending moment. Exceptional bending moments occur only a few times in the lifetime of a concrete sleeper and bearer.

The third stage of the test bending moment is the ultimate bending moment due to accidental impacts, calculated by multiplying the positive characteristic bending moment $M_{k,r,pos}$ by coefficient k_2.

4.2.2 Cracks at centre part (prestressed monoblock sleepers or bearers)

Wheel loads generate positive and negative bending over the central length of the sleeper.

The required flexural strength over the central part of the sleeper is determined from the bending moment induced by the dynamic rail seat load and depends on the distribution of the ballast reaction.

When subjected to the negative static test bending moment, there shall be no first crack at the tensile face of the concrete sleeper or bearer as required in EN 13230-1:2016, 7.2.

If permitted by the purchaser, controlled cracking of sleepers or bearers in track can be accepted. In that case, residual crack opening and fatigue shall be checked according to method agreed by the purchaser.

4.2.3 Cracks for tests for negative bending under rail seat or positive bending at centre part

Additional bending tests with crack measurement can be required to check the general design or manufacture of the sleeper or for specific loads imposed during track installation.

4.3 Section design of sleeper

The section design shall follow prescriptions of EN 13230-1:2016, Clause 6.

4.4 Durability of sleeper

Requirements for providing durability are included in EN 13230-1.

5 Design parameters

5.1 Maintenance

5.1.1 Track and rolling stock quality

The maintenance policy for both track and rolling stock will influence the loads imposed on the track. Track geometry quality should be according to EN 13848-1 and EN 13848-5 and rolling stock maintenance policies will define the maximum tolerance for wheel flats and their out of roundness.

These criteria together with maximum train speed shall be taken into account by the purchaser to determine:

— the dynamic rail seat load;

— the impact factor for exceptional loads;

— the characteristic bending moments and test bending moments.

5.1.2 Distribution of the vertical load in the longitudinal direction

The distribution of the wheel load over adjacent sleepers along the track depends on the vertical bending stiffness of the rail, sleeper spacing, rail pad stiffness and the stiffness of ballast or subsoil.

Factor k_d can be determined applying the "elastic beam on elastic foundation" theory with a constant bedding modulus along the rail.

In addition, factor k_r represents the variation of the sleeper reaction in the ballast due to longitudinal supports faults along the track. This factor should be evaluated by measurements in track.

It is the responsibility of the purchaser to determine the coefficients k_d and k_r.

Recommendations for factors k_d and k_r are given in Annex A.

5.1.3 Distribution of ballast reaction along the length of the sleeper

The length and the width of the sleeper can influence the effective stiffness reaction of the ballast and the longitudinal distribution of wheel load along the length of the sleeper. Moreover variation in ballast reaction can be caused by characteristic of sub grade under ballast, by variation of ballast stiffness due to tamping or freezing, or by ballast quality (size of ballast, stone characteristics and fouling of ballast layer).

When uniform ballast reaction or bedding modulus are assumed, load distribution may be changed considerably in track due to the random formation of local load contact points within the ballast. The difference between the bending moments calculated with a simplified design model and the characteristic bending moments measured in track shall be taken into account by factors $k_{i,r}$ at rail seat section or $k_{i,c}$ for bending moment increase at the centre.

It is the responsibility of the purchaser to determine the coefficients $k_{i,r}$ and $k_{i,c}$.

Recommendations for factors $k_{i,r}$ and $k_{i,c}$ are given in Annex A.

5.2 Track laying conditions

5.2.1 Mass of sleeper

The mass of sleeper contributes to lateral resistance of track. Transportation to work site and track installation methods can determine the maximum mass.

5.2.2 Length of sleeper

The length of sleeper contributes to longitudinal and lateral distribution of ballast reaction. Transportation to work site and track installation methods can determine the maximum length.

5.2.3 Depth of sleeper

Depth of sleeper contributes to section modulus of sleepers and to longitudinal and lateral resistance of track. Transportation to work site, available overhead clearances and track installation methods can determine the depth.

5.2.4 Track installation methods

During track installation, loadings may occur which are different from those that occur from the operation of regular service trains. Care should be taken that there is no excessive bending of the concrete sleeper.