

Design guidelines

Technical Specification – Sleepers, USPs and Fastenings

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1. Scope

This Technical Specification describes the minimum requirements of prestressed monoblock concrete sleepers and prestressed bearers to be supplied to RB Rail AS. This set of requirements enables the producer of the sleepers and bearers to design and manufacture the sleepers and bearers that meet RB Rail AS requirements. Requirements have been set to sleepers and bearers, fastening systems and under sleeper pads. Additionally, minimum Quality Assurance and Quality Control (QA/QC) requirements have been established which are mandatory for the producer of the sleepers and bearers.

2. General requirements

Sleepers, bearers, fastening systems and under sleeper pads to be supplied to RB Rail AS shall fulfill the requirements described in this Technical Specification and European Commission Regulation No 1299/2014 (Technical Specifications of Interoperability – TSI).

The sleepers and bearers shall be supplied with fastenings, rail pads and under sleeper pads (USPs) fitted to the sleepers and bearers to form one element.

The materials used for sleepers' and bearers' production shall fulfill the requirements described in EN 13230-1 Clause 5 and this Technical Specification.

The producer shall submit RB Rail AS all information stated in Clause 4.4.3 of EN 13230-1:2016.

Prior to supplying the sleepers and bearers, the producer must conduct Design Approval Testing on the sleepers and bearers in accordance with EN 13230-1 Clause 7. The producer shall submit Design Approval Testing Report to the RB Rail AS which shall confirm compliance with this Technical Specification.

The producer shall operate and maintain factory Quality System in accordance with EN 13230-1 Clause 8.

Sleepers and bearers for main line, expansion joints, turnouts, etc. shall be designed to withstand the load and speed conditions described in Table 1 throughout the Design Working Life of 50 years. Designing of the sleepers shall be done in accordance with EN 13230-6:2020 taking into account the worst loading condition described in Table 1.

Axle load, tons (t)	Speed, km/h
25 t	≤ 120
22,5 t	> 120 and ≤ 220
18 t	> 220 and ≤ 300

1. TABLE 1 RAIL BALTICA DESIGN AXLE LOADS AND OPERATIONAL SPEEDS

2.1. Sleepers

The type of sleepers is prestressed concrete monoblock sleepers (EN 13230-2).

The sleepers shall be designed in accordance with EN 13230-6 and produced in accordance with EN 13230-1 and EN 13230-2, taking into account the requirements stated in this Technical Specification.

2.2. Bearers

The type of bearers is prestressed concrete bearers (EN 13230-4).

The bearers shall be designed in accordance with EN 13230-6 and produced in accordance with EN 13230-1 and EN 13230-4, taking into account the requirements stated in this Technical Specification.

3. Functional requirements

3.1. Characteristic bending moments

3.1.1. Sleepers

Sleepers shall be designed by the producer in accordance with EN 13230-6. Applicable characteristic bending moments with impact coefficients and test coefficient are described in Table 2.

The characteristic bending moments depend on the sleeper design and geometry. Factors stated in Table 3 shall be taken into account for designing the sleepers with length of 2600 mm. The input parameters stated in Table 3 shall be taken into account when designing the sleepers with other lengths.

Property	Symbol	Requirement
Positive characteristic bending moment at rail seat	$M_{k,r,pos}$	≥ 16 kNm
Positive characteristic bending moment at centre section	$M_{k,c,pos}$	$\geq 7,50$ kNm
Negative characteristic bending moment at centre section	$M_{k,c,neg}$	≥ -9 kNm
Negative characteristic bending moment at rail seat	$M_{k,r,neg}$	NR (shall be declared by the producer)
Static coefficient to be used for calculation of $Fr_{0,05}$ test load	k_{1s}	2,4
Static coefficient to be used for calculation of $Fr_{0,5}$ or Fr_B test load	k_{2s}	3,3
Dynamic coefficient to be used for calculation of $Fr_{0,05}$ test load	k_{1d}	2,0
Dynamic coefficient to be used for calculation of $Fr_{0,5}$ or Fr_B test load	k_{2d}	2,9
Static coefficient to be used for calculating Fr_B at the end of fatigue test	k_3	3,3
Factor used for calculation of acceptance criteria for first crack formation in static test	k_t	1,5

2. TABLE 2. CHARACTERISTIC BENDING MOMENTS AND APPLICABLE COEFFICIENTS FOR SLEEPERS WITH LENGTH OF 2600 MM

Property	Symbol	Value
Nominal axle load	A_{nom}	250 kN
Dynamic increment factor	k_v	0,46
Attenuation factor	k_p	1,0
Longitudinal load distribution factor	k_d	0,38
Support faults factor	k_r	1,35
	$k_{i,c}$	2

Property	Symbol	Value
	$k_{i,r}$	1,6

3. TABLE 3. CHARACTERISTIC BENDING MOMENTS AND APPLICABLE COEFFICIENTS FOR SLEEPERS WITH LENGTH OF 2600 MM

3.1.2. Bearers

Bearers shall be designed by the producer in accordance with EN 13230-6.

Applicable characteristic bending moments and testing moments are described in Table 4.

Property	Symbol	Requirement
Positive characteristic bending moment	$M_{k,b,pos}$	22,50 kNm
Negative characteristic bending moment	$M_{k,b,neg}$	- 22,50 kNm
Positive testing bending moment	$M_{t,pos}$	32 kNm
Negative testing bending moment	$M_{t,neg}$	-30 kNm

4. TABLE 4. CHARACTERISTIC BENDING MOMENTS AND TESTING MOMENTS FOR BEARER DESIGN

3.2. Dimensions

Rail profile is 60E2 as described in EN 13674-1:2011+A1:2017. Rail profile dimensions are described in Figure A.24 in the Annex A of EN 13674-1:2011+A1:2017.

Rail gauge is 1435 mm.

Rail inclination is 1:40.

Sleeper spacing of 600 mm (from center to center) shall be considered.

Sleepers shall be produced and supplied in accordance with the dimensions Table 5. Maximum allowable tolerances to other geometric properties shall be in accordance with EN 13230-1:2016 Table 1.

Property	Requirement
Overall length of the concrete element (L)	2600 mm
Minimum bottom width (b_1)	≥ 300 mm
Minimum top width (b_2)	170 mm
Maximum height at rail seat (hp)	≤ 220 mm
Inclination of the rail seat	1:40
Minimum nominal weight of the sleeper (W_{nom}), incl. fastening system	$W_{min} \geq 300$ kg

5. TABLE 1. GENERAL GEOMETRIC PROPERTIES

4. Materials

4.1. General

The materials used for producing the sleepers and bearers shall be selected according to requirements stated in EN 13230-1:2016 Clause 5 and this Technical Specification. Special attention shall be paid to frost resistance of the concrete and resistance to alkali-silica reaction (ASR). In order to avoid ASR, one of the following conditions shall be met while deciding the final concrete mixture recipe:

- a) Limiting the total alkali content of the cement, stated as Na₂O equivalent to ≤ 0,60 %, or;
- b) Limiting the total mass of reactive alkalis in the concrete to ≤ 3,0 kg/m³.

4.2. Concrete

Concrete used for sleeper and bearer production shall be produced in accordance with EN 206. The Assessment and Verification of Constancy of Performance (AVCP) level of the concrete production shall be 2+ (AVCP level 2+). Minimum concrete properties are described in Table 6.

Property	Value
Minimum compressive strength class	C50/60
Maximum water/cement ratio, in mass	0,45
Minimum cement content	300 kg/m ³
Resistance to freezing and thawing CEN/TS 12390-9	S56 ≤ 0,20 kg/m ² or S56 ≤ 0,50 kg/m ² if S56/S28 is ≤ 2
Porosity EN 13230-1 Annex C	V _p ≤ 12 %
Minimum compressive strength class	C50/60

6. TABLE 6. MINIMUM CONCRETE REQUIREMENTS

The Production of sleepers and bearers shall be done in accordance with EN 13230-1 Clause 6.2.

Aggregates used concrete production shall fulfill the requirements stated in Clause “Aggregates” of this Technical Specification.

Cement to be used for concrete production shall fulfill the requirements stated in Clause “Cement” of this Technical Specification.

Using admixtures for concrete production is only allowed in justified cases if it's agreed and accepted by RB Rail AS. The cost of using admixture(s) shall not be compensated by RB Rail AS. All admixtures shall conform to EN 934-2. Admixtures which are not within the scope of EN 934-2 shall conform to EN 934-1 general requirements.

Heat treatment is allowed if it complies with the requirements described in EN 13230-1 Clause 6.2.3 and the temperature is monitored during the curing process continuously.

Surface finish of the sleepers and bearers shall fulfill the requirements described in EN 13230-1 Clause 6.3 and Annex E.

4.2.1. Aggregates

Aggregates shall be produced in accordance with EN 12620. The Assessment and Verification of Constancy of Performance (AVCP) level of the aggregate production shall be 2+.

Producer shall provide the Client information which is described in EN 13230-1, Clause 5.3.

Aggregates shall fulfill at least F₂ frost resistance category (determined in accordance with EN 1367-1) and LA₃₅ (determined in accordance with EN 1097-2).

4.2.2. Cement

Cement used for producing the concrete for sleepers and bearers shall be produced in accordance with EN 197-1. The Assessment and Verification of Constancy of Performance (AVCP) level of the cement production shall be 1+.

Only CEM I cement can be used for concrete production.

Cement minimum strength-grade class shall be $\geq 42,5$.

Sulfur trioxide content of the cement % by mass shall be $\leq 4,0$ %.

4.2.3. Concrete surface finish requirements

Concrete surface finish shall be in accordance with EN 13230-1 Clause 6.3 and Annex E.

5. Under Sleeper Pads

The sleepers shall be equipped with elastoplastic Under Sleeper Pads (USPs) which shall be produced in accordance with EN 16730. Applicable track category is TC3.

The USP shall cover the entire bottom (base) area of the sleeper (i.e. including the center section). The distance from the edges of the bottom (base) of the sleeper shall be 15 ± 5 mm.

Thickness of the USP without mounting mesh shall be 5 to 10 mm. Production tolerance of the USP thickness shall be ± 1 mm.

Declared static bedding modulus (C_{stat}) value shall be within the range of $0,30 \text{ N/mm}^3 \leq C_{stat} \leq 0,40 \text{ N/mm}^3$. The static bedding modulus shall be assessed in accordance with EN 16730 Clause 5.3.2. Allowable tolerance compared with declared value is $\pm 20\%$.

Declared low frequency dynamic bedding modulus ($C_{dyn,5\text{Hz}}$) of USP alone shall be within the range of $0,60 \text{ N/mm}^3 \leq C_{dyn,5\text{Hz}} \leq 0,70 \text{ N/mm}^3$. Allowable tolerance compared with declared value is $\pm 20\%$.

Declared low frequency dynamic bedding modulus ($C_{dyn,10\text{Hz}}$) of USP alone shall be within the range of $0,60 \text{ N/mm}^3 \leq C_{dyn,10\text{Hz}} \leq 0,70 \text{ N/mm}^3$. Allowable tolerance compared with declared value is $\pm 20\%$.

The tensile strength of the USP material shall be $\geq 2 \text{ N/mm}^2$.

The sleepers and bearers shall be stackable during the transportation and storage. Minimum allowable number of stacked sleepers shall be 15 and the maximum load shall be at least $0,8 \text{ N/mm}^2$.

USPs shall be embedded onto the sleepers and bearers during the production phase. The USPs shall be equipped with suitable mounting system (e.g. mesh, etc.) to ensure strong and durable adhesion to the sleepers and bearers.

The average bonding (pull out) strength (σ_{av}) value between sleeper and USP shall be $\geq 0,50 \text{ N/mm}^2$. Absolute minimum allowable bonding strength (σ_{min}) shall be $\geq 0,40 \text{ N/mm}^2$. Pull out testing shall be carried out according to EN 16730 Clause 5.5.2.

The durability of USP to fatigue shall be assessed according to EN 16730 Annex L. Acceptance criteria is following:

- a) After the testing, the USP shall not show any signs of perforation, cracking or other damage.
- b) The mass of the sleeper shall not reduce more than 0,5%.
- c) The static and low frequency dynamic stiffness of USP shall not change by more than -20% to +15%.

The durability of USP to severe environmental conditions shall be assessed according to EN 16730 Annex N. Acceptance criteria is following:

- a) The static and low frequency dynamic stiffness of USP shall not change by more than 15%.
- b) Minimum bonding strength σ_{mv} shall be $\geq 0,40 \text{ N/mm}^2$.

USP shall have excellent resistance to water (DIN 53428).

USP shall have good resistance to chemical agents (DIN 53428).

USP shall have class E resistance to fire (EN ISO 11925-2)

USP shall have good resistance to hydrocarbons (DIN 53428)

USP shall have excellent resistance to ozone (DIN 53428)

6. Fastenings

Fastening systems for sleepers and bearers shall be produced in accordance with EN 13481-2. The fastening system category shall be D on main line and category C on curves with radius $R \leq 400$ m.

All components of the fastening systems shall be fit for their purposes.

Fastening system shall be equipped with system to avoid tilting/tipping.

Elastic fasteners and its' components shall be protected against corrosion, either coated or galvanized.

The fastening system shall be easily released and replaced.

The fastening system shall ensure resilient pads are kept in place under the rail foot. The system shall provide the same stiffness performances all along its design life.

Fastening system shall allow at least following lateral and vertical adjustment:

Lateral adjustment ± 5 mm

Bolted baseplates shall not be used on concrete sleepers in plain line.

Where bolted baseplates are required, for example in turnouts, female inserts in the concrete bearers shall be used.

Fastening systems shall fulfill the requirements described in Table 7.

Property	Symbol	Requirement
Longitudinal rail restraint	EN 13481-2 Clause 5.1	≥ 9 kN (Category D) ≥ 7 kN (Category C)
Torsional resistance	EN 13481-2 Clause 5.2	Declared value
Rail pad static stiffness	EN 13481-2 Clause 5.4	≥ 30 kN/mm
Effect of repeated loading	EN 13481-2 Clause 5.5	Longitudinal rail restraint change ≤ 20 %. Vertical static stiffness change ≤ 25 %. Clamping force change ≤ 20 %.
Electrical resistance of fastening system and sleeper	EN 13481-2 Clause 5.6	≥ 5 k Ω c
Effect of exposure to severe environmental conditions	EN 13481-2 Clause 5.7	Following exposure to the salt spray test, the fastening assembly shall be capable of being dismantled without failure of any component and re-assembled using manual tools provided for this purpose
Dimensions	EN 13481-2 Clause 5.7	The overall dimensions shall be within the envelope shown in EN 13481-2 Figure 2. This requirement does not apply in case web support fastening system is used.
Effect of fastening system tolerances on track gauge	EN 13481-2 Clause 5.9	Calculated to be within ± 1 mm

Property	Symbol	Requirement
Clamping force (per clip)	EN 13481-2, Ch. 5.10	≥ 10 kN

7. TABLE 7. FASTENING SYSTEM REQUIREMENTS

7. Quality System and Documentation

EC declaration of conformity shall be submitted to RB Rail AS for all items and systems indicated in the European Commission Regulation No 1299/2014 (Technical Specifications of Interoperability – TSI).

The producer of sleepers and bearers shall implement and operate Quality System as described in EN 13230-1 Clause 8.

Prior to start of the production, the producer shall submit RB Rail AS a detailed overview of the production process and quality plan. Quality plan shall be aligned with EN 13230-1 Annex F.

The producer shall submit detailed drawings of the sleepers and bearers to RB Rail AS prior to delivery. All drawings shall be submitted both in “.dwg” and “.pdf” file formats. All drawings must be approved by RB Rail AS before production of the sleepers and bearers.

The producer shall submit Manufacturing Rules in accordance with EN 13230-2 Clause 5 (sleepers) and EN 13230-4 Clause 6 (bearers).

The producer shall maintain records of each order of sleepers. The records shall be retained by the producer for at least five years and must be available for inspection by RB Rail AS at any time. On request, this information shall be submitted to RB Rail AS. These records must include applicable material certificates and testing results for the following components:

- a) Aggregates
- b) Cement
- c) Admixtures (if any)
- d) Reinforcing steel
- e) Fastening systems
- f) Under Sleeper Pads

7.1. Testing and acceptance

Prior to proceeding with production, the sleepers and bearers are subjected to Design Approval Testing by the producer. The producer shall conduct Design Approval Testing according to EN 13230-1 and EN 13230-2 (sleepers) and EN 13230-4 (bearers). The testing shall include static, dynamic and fatigue testing of the sleepers and bearers, including optional parts of the tests. Test records from design approval testing shall be provided to RB Rail AS prior to delivery.

During the production phase, the producer shall organize routine testing of the sleepers and bearers in accordance with EN 13230-1 and EN 13230-2 (sleepers) and EN 13230-4 (bearers). These tests shall be done in the laboratories which are accredited in EN 17025. RB Rail AS can initiate additional testing that shall be organized by the producer or RB Rail AS. Test records from routine testing shall be retained by the supplier but must be available for inspection by RB Rail AS at any time.

Up to 0,5% of the produced sleepers can be subjected to quality control by RB Rail AS (for destructive testing). The price of the sleepers to be subjected to testing shall be included in the tendering price. No additional costs will be carried by the RB Rail AS.

8. Marking

Each sleeper and bearer shall be marked in accordance with EN 13230-1 Clause 6.4.

9. Storage and transportation

Sleepers shall be stored and transported in such a manner that sleepers or fastening components are not damaged.

During storage and transportation wooden shims with ≥ 50 mm thickness shall be used between the sleepers.

The producer of the sleepers shall supply RB Rail AS with special unloading equipment (if foreseen by the producer) and shall organize the delivery and unloading of the sleepers at the predetermined point of delivery indicated by the Client.