A division of Transnet SOC Limited

RAIL NETWORK – TECHNICAL

SPECIFICATION FOR COMPOSITE SLEEPERS

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1.0 INTRODUCTION

1.1. Sleepers provides support to track components, assists with stability and load distribution and provides mounting for the rail and signalling equipment.

1.2. This specification entails the technical requirements for sleepers manufactured by non-traditional materials (Composite Sleeper) for both track and bridges including universal.

1.3. The specification shall only be used for the procurement of composite sleepers that will be installed on track with the following parameters:

1.3.1. 20, 26 and 30 tons/ axle lines
1.3.2. SAR 48, SAR 57, 60E1 rail profiles
1.3.3. 1065 mm track gauge.

2.0 REFERENCED DOCUMENTS

2.1 BBB 0481 (Latest Version), Transnet Freight Rail Manual for Track Maintenance.
2.2 BBD 6241 Bridge Code.
2.3 ISO 12856-1:2014, Plastic railway sleepers for railway applications (railroad ties): Material Characteristics.
2.4 ISO 12856-2:2020, Plastic railway sleepers for railway applications (railroad ties): Products Testing.
2.5 AS 1085.22:2019, Railway track materials, Alternative material sleepers.
2.6 IRS:T59-2021, Indian Railway standard specification for composite sleepers.
2.7 JIS E 1203-2007, Synthetic Sleepers – Made from fiber reinforced foamed urethane.
2.8 BBB 9273 (Latest Version), Specification for rail fastening systems.

3.0 TERMS AND DEFINITIONS

For this specification the following definitions shall apply:

3.1 **Supplier**
An entity that wishes to be eligible to supply the composite sleepers to TFR.

Manufacturer
An entity that produces the desired goods and may or may not be the supplier.

Composite Sleeper / Synthetic Sleeper
A railway sleeper manufactured from multiple non-traditional constituents.

Third party
An entity, person or group besides the two primarily involved in entities which are TFR and the manufacturer/supplier.

4.0 TECHNICAL REQUIREMENTS

4.1 Material Requirements

4.1.1 Composite sleepers consists of multiple constituents. These constituents could include any recycled plastics, rubber and bitumen with glass reinforced fibres.

4.1.2 Reinforced fibres and other modifiers may be added to increase the mechanical properties of the sleeper. The direction of the reinforced fibres shall be transverse and longitudinal of the track to ensure mechanical strength (see Figure 1).

4.1.3 The constituents of the sleeper shall be at the manufacturer's discretion to enable the sleeper to conform with the requirements of TFR. The constituents used within the sleeper may not pose environmental concern and the supplier must specify the constituents source, testing, availability and quality.

4.1.4 The sleeper should be able to withstand temperature change for all South African four seasons across TFR lines (rail temperature -15 to 70 °C), must not be affected by moisture, must be UV resistant, fire resistant, abrasion resistant, resist decaying and able to withstand chemical spills like fuel, oil etc.

4.2 Design Requirements

4.2.1 The manufacturer shall comply with the following minimum design criteria for track, bridge and universal composite sleepers:

- Accommodate all rail profiles used within TFR (SAR 48, SAR 57 and 60E1)
- Must be able to accommodate the existing fastening system and must comply to the fastening specification BBF9273 latest version. E3131 if the system uses sole plates/ chairs on bridges, pandrol type or fist clip for track sleepers. Any alternatives fastening systems shall be compatible with the aforementioned specifications.
- Suitable for a track gauge of 1065 mm (±2mm).
- Demonstrate a cost effective life cycle when compared to concrete sleepers
- Sleeper must not warp/ bend due to in service operation and must be able to withstand ultra-violet (UV). Surface deprivation due to the UV light may not result in the sleeper being unusable.
- The sleeper may not have any visible surface defects in general and internal voids/ porosity will not be permissible (max: Ø 12.5 mm).
- Enable electrical insulation (min: 5 kΩ).
- Shearing strength of more than 7 MPa.
- Linear expansion coefficient should be less than $5 \cdot 10^{-5}/°C$. Note: The thermal expansion coefficient will influence track gauge.
- Provide resilience to the track.

- Fire resistant to mitigate the risk of sleeper replacement due to welding, grinding, bush fires, train breaks etc.
- Must be able to perform the intended duties of the conventional sleepers by accommodating the weight of the rolling stock (20, 26 and 30 tons/axle) and distributing the load accordingly.
- Where possible the sleepers must be marked/ indented with the follow markings:
    - Supplier name
    - Transnet Logo (Transnet shall provide the description of the logo)
    - Manufacturing date and batch number
    - Fastening identification (PY, P2, FY, F4 etc.) for track sleepers

4.3 Dimensions and Tolerance Requirements

4.3.1 Dimensions and tolerances for both bridge and track sleepers are indicated in Table 1. The supplier must submit drawings of the sleepers for approval by the Principal Engineer and it remains the responsibility of the supplier to ensure that the correct dimensions and tolerances is adhere to.

Table 1: Dimensions and Tolerances for Track and Bridge sleepers (mm)

	Track			**Bridge**		
	Dimensions	**Tolerances**		**Dimensions**	**Tolerances**	
Length	2200	+5	-5	2100	+5	-5
Width	300	+5	-5	250	+5	-5
Thickness	232/258	+5	-5	160/190	+2	-2

4.3.2 Universal sleepers shall be available in lengths specified in Table 2

Table 2: Dimensions and Tolerances for Universal sleepers (mm)

	Universal		
	Dimensions	**Tolerances**	
Length	2100 2400 2700 2800 3000 3200 3800 4200 6000	+5	-5
Width	300/265	+5	-5
Thickness	180/220	+5	-5

4.3.3 Rail seat flatness must be within 0.5 mm for track, bridge and universal sleepers.

4.4 Performance Requirements

4.4.1 The sleeper must be able to resist:

- Maximum lateral load of 80 kN and continuous load of 60 kN,
- Train speeds of up to 100 km/h,
- Rail inclination of 1:20,
- Curve radius as small as 110 m

4.4.2 The sleepers must be tested according to TFR requirements as per this specification and/or according to the relevant ISO and SANS standards or equivalent. The laboratory testing is subject to change as time progresses to simulate track conditions.

4.4.3 TFR reserves the right to perform quality tests on the sleepers at their track testing laboratory and the supplier must provide all the required samples (5 sleepers min).

4.4.4 Each sleeper shall be dimensionally check prior to testing and should conform to the tolerances specified in Table 1 and Table 2

4.4.5 The tests to be performed should be done according to the ISO 12856-2 or equivalent specifications and must include:

Table 3: Required tests for each sleeper type

	Track	Bridge	Universal
Static Load Test	X	X	X
Dynamic Fatigue Test	X	X	X
Porosity/ Void Test	X	X	X
Flammability	X	X	X
Screwing/ Torque test	X	X	X
Electrical Conductivity	X	X	X
Slant Test	Optional	Optional	Optional
Static Pull - Out	X	X	X
Dynamic Pull - Out	Optional	Optional	Optional
Weatherability Test	X	X	X
Water Absorption Test	X	X	X
Impact Test	X	X	X

4.4.5.1 Static Load Test

The test piece shall be set-up in a similar configuration as seen in Figure 2, Figure 3, Figure 4 and Figure 5.

Table 4: Static Test Conditions

Loading Characteristics	• Apply test load (P) until design moment is attained • Loading Rate = (20 - 25 kN/min)
Acceptance Criteria	• Failure stress > Design stress • Bending load ≥ 170 kN, • Bending strength ≥ 28 MPa • Plastic deformation ≤ 0.5 mm • Shearing strength ≥ 7 MPa • No defects like tears, cracks etc. may be present on the surface

4.4.5.2 Dynamic Fatigue Testing

This test assesses the structural integrity of the sleeper and the rail seat abrasion. The test piece shall be set-up in a similar configuration as seen in Figure 2, Figure 3, Figure 4 and Figure 5 respectively.

Table 5: Dynamic Test Conditions

Loading Characteristics	• Apply test load (P) until design moment is attained • Frequency of ± 5 Hz • Period = 2 million cycles
Acceptance Criteria	• Plastic deformation ≤ 0.5 mm on the rail seat • Plastic deformation ≤ 2 mm midspan • No defects like tears, cracks etc. may be present on the surface of the sleeper

4.4.5.3 Porosity/ Void test

Table 6: Porosity/ Void Test Conditions

Test Characteristics	• Each sleeper must be x-rayed after manufacturing
Acceptance Criteria	• No porosity bigger than 12.5 mm in diameter and 150 mm in length may be present within.

4.4.5.4 Flammability

During this test it is important to determine the ignitability, rate of heat release and flame spread.

Table 7: Flammability Test Conditions

Acceptance Criteria	• The ignitability should not take place after 20 seconds of introducing a source.

4.4.5.5 Screwing/ Torque Test

This test ensures that the sleeper can withstand the appropriate torque settings required to fasten the rail to the sleeper.

Table 8: Screw Test Conditions

Test Characteristics	• Install coach screws and torque until fracture
Acceptance Criteria	• Screw torque should be higher than the sleeper design torque. • The sleeper may not show any significant damage after the test

4.4.5.6 Electrical Conductivity

Table 9: Electrical Test Conditions

Test Characteristics	• The sleepers shall be equipped with baseplate, bolts, coach screws and clips. • Test Dry condition • Test Wet conditions
Acceptance Criteria	• The sleepers should have electrical resistivity of ≥ 5 kΩ for both dry and wet conditions.

4.4.5.7 Slant Testing

This test, tests the assembly of the fastening system on the sleeper while subjected to repetitive loads.

Table 10: Slant Test Conditions

Test Characteristics	• Record rail temperature for duration of test • Period = 2 million cycles • Min load = 5 kN • Max load = 120 kN
Acceptance Criteria	• Temperature may not exceed 60 °C • No visible damage to fastening system • No damage > 0.25 mm on rail seat area

4.4.5.8 Static Pull-out Test

This test involves the application of force to remove the coach screws from the sleeper.

Table 11: Static pull-out Test Conditions

Test Characteristics	• Load 1 = 5 kN • Load 2 = 30 kN
Acceptance Criteria	• Average plastic deformation of coach screw < 0.5 mm • Static withdrawal force > 30 kN • No visible damage on sleeper after load 1 • No significant damage after load 2

4.4.5.9 Dynamic Pull-out Test

This test involves the application of force to remove the coach screw on a dynamic basis.

Table 12: Dynamic pull-out Test Conditions

Test Characteristics	• 2 million cycles • 5 – 15 kN at 5 Hz
Acceptance Criteria	• Average plastic deformation of coach screw < 2 mm • Sleeper must complete the test without failure • No significant damage after test

4.4.5.10 Weatherability Test (UV resistance)

This test simulates the effect of ultra violet (UV) on the performance of the sleeper.

Table 13: Weatherability Test Conditions

Test Characteristics	• Xenon-arc lamp type or equivalent weatherometer • Direction of the radiation shall be on the loading side and sleeper ends as illustrated in Figure 6 and Figure 7 • Weatherometer temperature (31 – 41)℃ • Cycles will consist of 102 min radiation followed by 18 min radiation and spray for a total of 3300 hours. • Apply static loading and dynamic fatigue testing.
Acceptance Criteria	• Static and Dynamic test acceptance criteria should be met.

4.4.5.11 Water Absorption Test

This test measures the amount of water absorbed by the sleeper.

Table 14: Water absorption Test Conditions

Test Characteristics	• Measure mass of sleeper piece approx. (30 x 30 x 100)mm prior to testing. • Submerge sleeper piece in fresh water at room temperature for 24h. • Measure mass after 24h and compare to initial mass.
Acceptance Criteria	• ≤ $10 \cdot 10^{-5} g/mm^2$

4.4.5.12 Impact Test

This test simulates the effect of a derailment with the impact of the wheel on the sleeper. See Figure 8 for test set up.

Table 15: Impact Test Conditions

Test Characteristics	• Wheel flange shaped weight = (495 – 505) kg • Height ≥ 750 mm • Test position A • Number of drops = 2
Acceptance Criteria	• Damage in the drop zone (chipping/ recess) may not exceed 33 % of the sleeper thickness • Only a recess should form, no cracks may be present on the surface of the sleeper after testing

5 COMPLIANCE REQUIREMENTS

5.1 User Requirements

5.1.1 The constituents of the sleeper shall be disclosed to TFR.

5.1.2 TFR shall not disclose such a composition to other manufacturers or third party and shall treat such as intellectual property.

5.1.3 The sleeper shall be eco-friendly and shall possess suitable microbicidal additives to resist termite, rot and bacterial growth etc. on the sleeper.

5.1.4 The supplier shall provide Material Safety Data Sheets (MSDS) of the product as well as declare all other safety and environmental related issues pertaining to the product.

5.2 General Requirements

5.2.1 The manufacturer's sleeper factory/plant shall possess an ISO 9001 (latest) or equivalent quality management system.

5.2.2 The supplier/manufacturer shall have approved testing methods according to the ISO 12856-2 standard or equivalent for the product and must have a product manual.

5.2.3 Extensive testing of the sleepers shall be carried out for quality and consistency by the supplier prior to its implementation on the TFR railway lines.

5.2.4 The supplier/manufacturer must provide TFR with:

- The necessary maintenance procedure/ schedule or all relevant manuals,
- Warranty period,
- Drawings/ Dimensions,
- Technical properties,
- The expected life span of the sleepers,
- Handling procedure,
- Details of the constituents and all other relevant information as stipulated in this specification

5.2.5 All drawings shall be signed by the Principal Engineer once the products has been approved.

5.2.6 The manufacturer shall provide technical support to TFR should it be required.

5.2.7 In the case whereby the supplier is not the direct manufacturer, a Memorandum of Understanding (MOU) shall be supplied to Transnet Freight Rail.

6 Appendix A

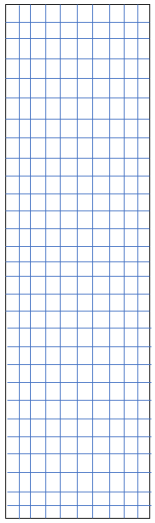

Figure 1: Internal Fibre Orientation Illustration (Shrestha & Duarte, 2021)

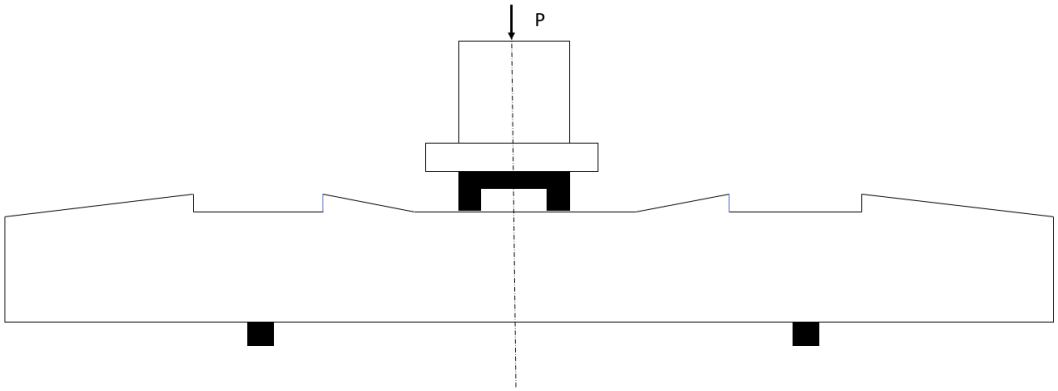

Figure 2: Track sleeper test setup for static and dynamic testing (Midspan)

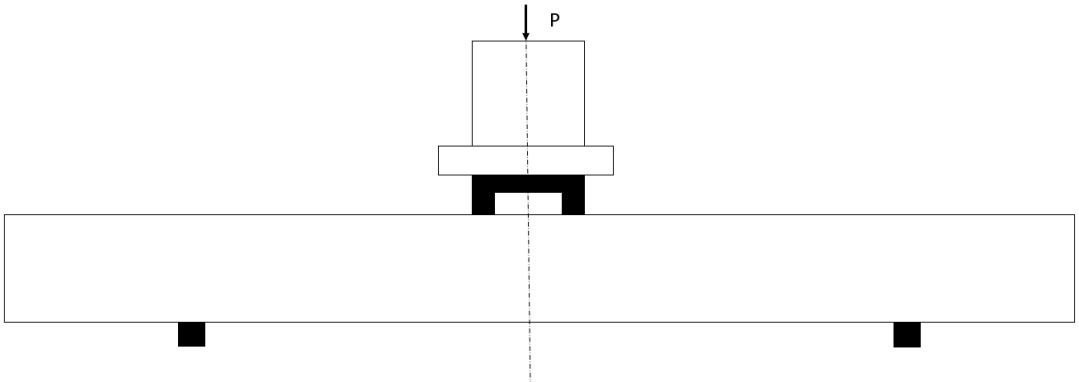

Figure 3: Bridge/ Universal sleeper test setup for static and dynamic testing (Midspan)

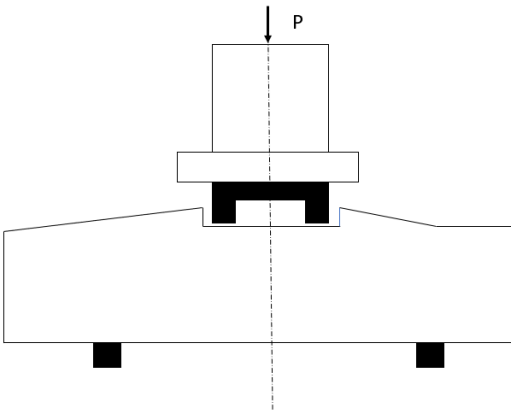

Figure 4: Track sleeper test setup for static and dynamic testing (Rail Seat)

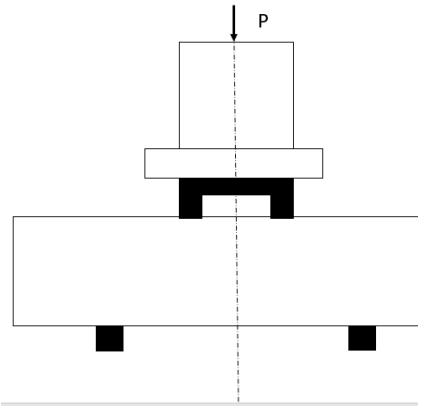

Figure 5: Bridge/ Universal sleeper test setup for static and dynamic testing (Rail Seat)

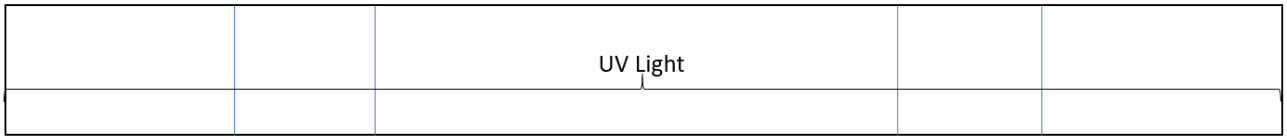

Figure 6: Weatherability light location 1

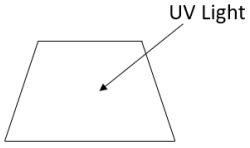

Figure 7: Weatherability light location 2

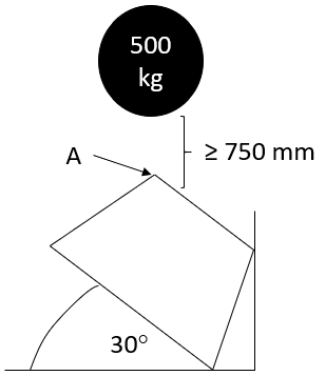

Figure 8: Test setup for impact testing