



SPOORNET SPECIFICATION

**Spoornet : PWM 2/5
(Issued March 1996)**

**SPECIFICATION FOR MONOLITHIC PRE-STRESSED
CONCRETE SLEEPERS USED ON 1 065 mm GAUGE RAILWAY
TRACK**

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1. SCOPE

This specification is compiled for monolithic pre-stressed concrete sleepers used on a 1 065 mm gauge railway track.

2. DEFINITION

“Chief Engineer” means the Chief Engineer, Infrastructure of Spoornet or any other officer of Spoornet lawfully acting on his behalf.

3. ACCEPTABLE DESIGNS

- 3.1. The reinforcement of the sleeper is to be designed by the Tenderer and sleepers to this design must have been satisfactorily tested by Spoornet.
- 3.2. The design offered must have passed the experimental stage and at the time of submission of the tender, a minimum of 3 000 sleepers of the design must be in use in running lines for at least 2 years.

4. ELASTIC FASTENINGS

- 4.1. TENDERERS MUST SUBMIT ALTERNATIVE QUOTATIONS FOR PROPRIETARY BRANDS OF FASTENINGS PRESENTLY IN USE ON SPOORNET.
- 4.2. The design of the sleepers must make provision for elastic fastenings according to Specification CCE 1/5/2 (July 1976).
- 4.3. In design of elastic fastenings where shoulders for securing the rails in position are cast into the sleeper, particular attention must be paid to fixing these shoulders in position in such a way that they are firmly embedded and will not become loose.

- 4.4. Where ferrous components of the fastenings to be cast into the sleeper require a hot-dip zinc (galvanised), this shall be done prior to casting into the sleeper and to SABS 763-1988 . Any minimum internal diameters specified by the fastening manufacturer shall be adhered to.
- 4.5. Components of the fastenings required to be cast into the sleeper must be placed in the sleeper to the dimensions and within the tolerances specified by the manufacturer of the fastenings.
- 4.6. Any components of the fastenings that are to be cast into the sleeper are to be supplied by the manufacturer of the sleeper and the price quoted for the sleeper must include these components.

5. **SHAPE AND SIZE OF SLEEPER**

- 5.1. The sleeper shall be of the shape and dimensions as indicated on the following drawings :

Sleeper type	Drawing
P2	E3303 sheet 1
F4	E3303 sheet 2
PY	E3318 sheet 1
FY	E3318 sheet 2
PA(paved)	E3343 sheet 1
PYwing	Based on E3318 sheet 1

6. **DESIGN REQUIREMENTS**

- 6.1. The sleeper shall be reinforced to withstand the following moments of resistance without exceeding the maximum permissible stress.

Sleeper type	Positive moment Railseat kN.m	Negative moment centre of sleeper kN.m
P2/F4 (2057 mm)	11.2	10.2
PY/FY/PYwing (2200 mm)	17.2	13.75
PA	11.2	10.2

- 6.2. A maximum **tensile** concrete stress (concrete strength 60 MPa and higher) not exceeding 3.5 MPa (SABS 0100-1:1992) will be permitted in the computation of the above resistance moments.
- 6.3. The maximum permissible **compressive** stress in the concrete due to the stressing force alone, is not to exceed 11,75 MPa.
- 6.4. Tenders must be accompanied by detailed plans and design calculations proving that the minimum resistance moments have been fully provided for.
- 6.5. Only designs using bonded reinforcement will be accepted and only reinforcement of a deformed design approved by the Chief Engineer will be accepted.
- 6.6. Where positive end anchorage is provided, plain reinforcement can be used.
- 6.7. Tenderers are asked to give details of the minimum ultimate tensile strength of the reinforcing steel to be used.

Tenderers are also asked to give details of the initial and final stresses in the reinforcement. These should not exceed the following values :-

- (a) Initial stress - 75% of minimum ultimate stress.
- (b) Final stress - 60% of minimum ultimate stress.

7. *BENDING TEST REQUIREMENTS*

- 7.1. In order to verify the resistance against tension cracks, the accepted sleeper design must pass dynamic production control tests for:
 - 7.1.1. *Positive and negative bending at midspan, and*
 - 7.1.2. *Positive bending under the rail seat.*
 - 7.1.3. The sample size for dynamic production control tests will be determined by Spoornet for every manufacturing plant.
- 7.2. Tenderers are therefore required to submit a detailed analysis specifying the magnitude of the three resistance moments, computed for a tensile concrete stress of 6,2 MPa. No visible cracking must occur before these bending moment values have been reached.

7.3. The offers must also contain details of the proposed testing arrangement, viz. disposition of any type of supports, number and points of application of the test loads including the magnitude of the test loads to produce the bending moments specified above. The suggested test arrangement must be approved by the Chief Engineer, and may be modified to suit Spoornet's requirements after which it will form part of this specification.

7.4. Pre-tensioned sleepers shall be tested as specified below :

7.4.1. The test load shall be applied at rate not exceeding 20 kN per minute.

7.4.2. The load (P), required to produce the specified design moment, may be applied at a faster rate than specified in (7.4.1).

The loading shall then be continued at the rate prescribed in 7.4.1 , until the first crack becomes visible. If the ratio of this load (P1) to the load (P2), which is the theoretical no crack load at which the tensile stress in the concrete is 6,2 MPa, is less than 1,0 the sleeper has failed.

(iii) Should any sleeper fail in (ii) above, Spoornet reserves the right either :

- (a) To reject all the sleepers cast on the day with the failed test sleeper.
- (b) To order additional tests of sleepers from the day's production of the sleepers concerned at no cost.

A minimum of 3 additional sleepers from the day's production shall be tested in the case of (b) above and the final acceptance or rejection of the day's production will be based on the results of these additional tests.

7.5. Bending moment tests on sleepers taken at random from normal production will be done in Spoornet's laboratory as and when required. Normally one sleeper of each type per contract per distribution term will be required and will be paid for by Spoornet except when further tests are required following the failure of a bending test.

Sleepers required for bending tests shall be delivered to Spoornet's laboratory by the manufacturer at no extra cost. These test sleepers shall also be removed by the manufacturer after completion of the tests or when making the next delivery.

8. *QUALITY OF GROUTING MORTAR*

All openings in the end faces of sleepers - used for stressing and anchoring purposes - must be carefully plugged against the ingress of moisture with cement mortar having a minimum compressive strength of 28 MPa after 28 days. See also Clause 12.6.

9. *TOLERANCES*

- 9.1. The tolerances shown on the following drawing shall be adhered to. Any changes in these tolerances shall require Spoornet's prior approval in writing.

Sleeper type	Drawing
P2	E3303 sheet 1
F4	E3303 sheet 2
PY	E3318 sheet 1
FY	E3318 sheet 2
PA	E3343 sheet 1
PYwing	Based on E3318 sheet 1

- 9.2. A tolerance of ± 5 mm shall apply to the length, width and depth of the concrete sleeper unless otherwise shown on the drawings.
- 9.3. The rail bearing surfaces on the sleeper must be true and flat to within 0,5 mm.
- 9.4. The cant of the rail seat shall be not less than 1:21 and not more than 1:18.
- 9.5. An adverse combination of the tolerance described in clause 9.4 and other tolerances affecting gauge will not be permissible. Therefore, when portions of the appropriate mass of rail together with the necessary fastenings (all correct to nominal size) are mounted on a sleeper or sleepers, the track gauge is to be correct within a tolerance of ± 1.5 mm.

Notwithstanding clause 1 of this specification, the track gauge referred to above shall be the following:

- a) 1064mm $\pm$ 1.5 mm for 48 kg/m rails on P2 sleepers
 - b) 1065mm $\pm$ 1.5 mm for 48 kg/m rails on F4 sleepers
 - c) 1066mm $\pm$ 1.5 mm for 60 kg/m rails on PY sleepers
 - d) 1067mm $\pm$ 1.5 mm for 60 kg/m rails on FY sleepers
 - e) 1065mm $\pm$ 1.5 mm for 48 kg/m rails on PA (paved) sleepers
 - f) 1066mm $\pm$ 1.5 mm for 60 kg/m rails on PYwing sleepers
- 9.6. The relative twist between the two rail seats shall not exceed an angle of 30 minutes.
- 9.7. See Appendix C for measuring apparatus.

10. ACCEPTANCE TESTS

- 10.1. Strength Defects : Should any bonding tests as described in Section 7 or concrete quality tests as described in Appendix B, fail to achieve the required results, that day's production must be held in reserve pending the outcome of further tests as specified in Section 7 and Appendix B.
- 10.2. Other defects : From each days production(lot), a minimum of 10% of the sleepers representative of the lot shall be made available for inspection.

The lot shall be accepted or rejected in accordance with the following procedure.

The "GO" and "NO GO" gauges, in conjunction with feeler or wedge type gauges where applicable, shall be used.

10.3. "A" Defects

- A1 Both defects B1 and B5 on the same sleeper
- A2 Both defects B2 and B4 on the same sleeper
- A3 Cast-in components of fastening too low (excessive clamping force)
- A4 Cast-in components of fastening too high (insufficient clamping force)
- A4 Total percentage of defects B4 + B5

10.4. "B" Defects

- B1 Excessive distance between outside shoulders
- B2 Insufficient distance between outside shoulders
- B3 Insufficient distance between shoulders of individual railseat
- B4 Rail seat cant steeper than 1:18
- B5 Rail seat cant flatter than 1:21
- B6 Excessive rail seat width

10.5. "C" Defects

- C1 Excessive distance between shoulders of individual rail seat
- C2 Twist exceeding 30 minutes.
- C3 Rail seat flatness not acceptable
- C4 Insufficient rail seat width
- C5 General appearance ect. as defined by Clause 11.1, 11.2, 12.2, 12.5 and 17.2
- C6 Total percentage of defects B1 + B2
- C7 Total percentage of defects B3 + C1
- C8 Total percentage of defects B6 + C4

10.6. The lot shall be rejected on the results of the sample if the percentage of checkpoints at which any individual defect occurs exceeds

- 6% for "A" defects
- 10% for "B" defects
- 15% for "C" defects

10.7. In all cases of rejection, full particulars shall be made available to the Chief Engineer.

11. MARKING

11.1. All sleepers are to be marked with the following:

- Spoornet Logo
- Year and month of manufacture
- Manufacturer's identification mark

- Sleeper fastening identification mark (eg. P2, PY, F4, FY, etc.)
- Place of manufacturing

11.2. Such marking must be indented lettering

12. MANUFACTURE OF SLEEPERS

- 12.1. Particular care is to be taken that the rail seats are smooth and even and within the tolerances laid down in Clause 9.3.
- 12.2. Spoornet will not accept sleepers where the cover is insufficient or where there are signs that the concrete is cracked. There shall be no projections of reinforcing which will cause tearing of clothing, or skin. These projections shall not exceed 1 mm.
- 12.3. Full details of the curing method to be adopted must be submitted with the tender and this will become part of this specification if approved.
- 12.4. Where vapour curing is used the following shall apply:
- (i) For at least two hours after casting the sleepers shall not be subjected to steam.
 - (ii) The temperature shall be raised by not more than 15⁰ C during the first hour of steaming.
 - (iii) After the first hour of steaming the rate of increase in temperature shall not exceed 10⁰ C per her hour.
 - (iv) When a temperature of 60 ⁰C has been reached it shall be maintained until a concrete strength of 30 MPa is reached. This temperature must not maintain for more than 6 hours.
 - (v) On no account shall the temperature exceed 60 ⁰C.
- 12.5. Reinforcement placed in pre-formed ducts is to be grouted by means of cement grout under pressure.
- 12.6. Recesses formed in the end faces of the sleeper for the purpose of tensioning the reinforcement are to be plugged with cement mortar.

13. CONTROLLING OF ALKALI-SILICA REACTION (ASR)

- 13.1. The alkali reactivity of aggregates used on the different manufacturing plants must be determined on a six monthly basis by an approved institution.
- 13.2. A copy of results (from each supplier) tested in 13.1 must be forward to Spoornet.
- 13.3. Spoornet reserves the right to draw a sample of aggregate on the manufacturing plant and test it for the alkali-reactivity.
- 13.4. For alkali-reactive aggregate the total content in kilogram Na_2O equivalent per cubic metre should not exceed the limits given in table below for aggregates from the different lithostratigraphic units.
- 13.5. To minimise the risk of ASR the following extenders can be used
 - Ground granulated blastfurnace slag (GGBS) at least 40% by mass
 - Fly ash (FA) at least 20% by mass

The limit of alkali content per cubic metre of concrete for South African aggregates from different lithostratigraphic units are as follows (Fulton's concrete Technology, 1994)

Rock type	Total Na_2O equivalent (kg/m^3)
• Witwatersrand Supergroup quartzite, shale	2.0
• Dolomite Group chert	2.8
• Malmesbury Group metasediments	2.1
• Table mountain Group orthoquartzite	2.8
• Bokkeveld Group arkose	2.8
• Natal Group Quartzite, sandstone	2.8
• Dwyka Formation tillite	2.8
• Enon Formation quartzite pebbles	2.8
• Quaternary	4.0

14. INFORMATION TO BE SUBMITTED BY TENDERERS

- 14.1. The place of manufacture of the concrete sleepers.
- 14.2. A brief description of their method of manufacture.

- 14.3. Detailed drawing including tolerances and the proposed method of marking the sleepers. These drawing shall bear the signature of approval of the fastening manufacturer that they comply in all respects with the requirements of that particular fastening system.
- 14.4. Detailed specifications which must lay down clearly the various strength and quality tests which apply to the sleepers.
- 14.5. Details of quality control organisation plus copies of the following quality control records shall be submitted to the Chief Engineer at the end of every month for the duration of the contract.
 - 14.5.1. Concrete cube tests.
 - 14.5.2. Bend tests on sleepers.
 - 14.5.3. Stressing equipment, Dynamometer, ect.
 - 14.5.4. Calibration of test machines (yearly) for (1) and (2) above.
 - 14.5.5. The manufacturer must comply to ISO 9002 and must be a certified ISO 9002 manufacturer.

15. DELIVERY AND PACKAGING

- 15.1. The sleepers shall be supplied loaded in railway trucks in the following manner :
 - (a) The sleepers are to be loaded rail seats uppermost transversely in layers: each layer being placed as nearly as possible in the middle of the truck.
 - (b) Each layer of sleepers including the bottom layer, is to rest on two strips of timber packing, each strip having a cross-section of not less than 38 mm x 38 mm.
- 15.2. The number of sleepers to be loaded in each truck shall be based on the permissible load of the vehicle but rounded off to the nearest multiple of 10.

16. GUARANTEE

The supplier will be required to guarantee the sleepers against all defects attributable to faulty manufacture, workmanship and quality of materials for a period of 3 years after the sleepers have been placed in the track.

Sleepers that fail in service before the expiration of the guarantee period shall be replaced free of charge at the initial point of delivery.

17. APPROVAL OF SLEEPERS AT POINT OF DELIVERY

17.1. Before proceeding with the bulk of the work, the manufacturer is to assemble a short length of track, comprising two lengths of new rails of the appropriate weight, approximately 6 m long, on 6 sleepers complete with fastenings (see 9.5).

17.2. The top and side surfaces of the sleeper shall present a smooth, uniform appearance. A random scattering of surface voids will not be a cause for rejection. Heavy concentrations of surface voids or evidence of improper mixing, vibrating or curing will be a cause for rejection.

The surface finish and texture of the sleepers in the approved short length of track shall be used as a comparison for the acceptable surface finish of sleepers in production.

17.3. Arrangements for the attendance of the Chief Engineer must be done through the Inspector. The two lengths of rail will be supplied free of charge to the manufacturer, together with the necessary fastenings.

17.4. The Inspector may, however, require the manufacture from time to time to set up the short length of track mentioned in clause 17.1 to check on the cant and gauge.

18. INSPECTION

18.1. Inspection shall be carried out in terms of Clause 25 of the "General Conditions of Promat Tenders, Contracts and Order" (Form U.S.7).

- 18.2. The attention of Tenderers is directed to paragraph (c) of Clause 25 referred to above whereby suppliers are required to supply, without charge to Spoornet, all tolls, gauges, templates and other equipment which may be required for checking the accuracy of the work.

APPENDICES

- A. Method of making and Curing 50 mm Concrete Test Cubes.
- B. Quality of Concrete
- C. Apparatus for Measuring Tolerances

APPENDIX A

METHOD OF MAKING AND CURING 150 mm CONCRETE TEST CUBES

1.1. Moulds

Moulds shall conform to current SABS specifications.

1.2. Vibrating Machine

The vibrating machine shall be capable of

- (a) Holding mould firmly attached to the machine during vibration,
- (b) Exercising vibration adequate to expel trapped air within 5 minutes so that no more air bubbles emerge.

1.3. Method of Manufacture

Approximately 20 kg of concrete to be taken where the mixed concrete reaches the sleeper mould. This concrete to be spooned into the cube mould during vibration, and the surface worked level, within 5 minutes. Vibration then to continue for another minute.

1.4. Duration of Manufacture

Vibration of test shall be completed within 45 minutes from the moment the dry cement enters the mixer.

1.5. After Manufacture

After vibration the filled mould shall be covered and transferred back to the sleeper production line for overnight curing. The mould to be removed between 8 and 24 hours after completion of vibration, and the cube marked for identification and stored in water until time of testing, unless otherwise agreed.

APPENDIX B

QUALITY OF CONCRETE

- 2.1 The crushing strength of 150 mm cubes of the concrete from which sleepers are made shall be at least 60 MPa at 28 days.

Sleepers may be accepted at earlier age: only where the manufacturer can adequately demonstrate by means of a control chart (a) there is a consistent significant increase in strength from 7 to 28 days in at least 2 month's production, and (b), the 7 day strength of the sleeper: concerned indicates, via the same control chart, that the specified 28 day strength will be reached without question.

- 2.2 One set of three cubes each shall be cast for every three hundred sleepers or part thereof from different batches of concrete at different intervals throughout the day.
- 2.3 The Contractor shall ensure that the testing machine is at all times in correct adjustment and properly calibrated. The Engineer shall have the right to check the calibration by crushing his own cubes on the Contractor's machine and on the Chief Engineer's testing machine and if there is any material discrepancy, the Engineer's calibration shall be accepted.
- 2.4 A test result shall be regarded as the average result for a set of 3 cubes. If the difference between the highest and lowest results for the 3 cubes exceeds 15 per cent of the average, the test shall be rejected, and the standard of testing shall be deemed inadequate if more than 10 per cent of the tests have to be rejected.

Test results shall be recorded on a control chart. For each day's group the average strength shall exceed the strength specified in 2.1 by an amount not less than standard deviation computed from the last 20 recorded averages, failing which the day's production must be separately stacked and held in reserve. In such cases the matter must be reported by the Inspector to the Chief Engineer who will decide whether the sleepers may be accepted. For that purpose additional tests on the sleepers themselves shall be required. A minimum of 3 sleepers manufactured during the day concerned shall be tested in accordance with section 7 of this specification.

APPENDIX "C"

APPARATUS FOR MEASURING TO tolerances

3.1 Twist and Rail Seat Cant

The relative twist between the rail seats and the rail seat cant shall be measured by means of the apparatus illustrated in sketch A or similar.

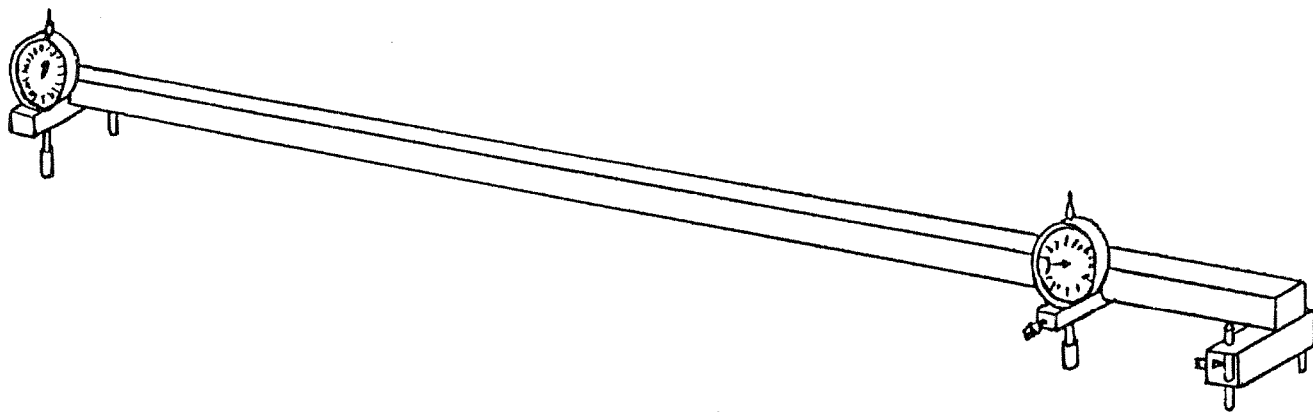
3.2 Rail Seat Width

Rail seat width shall be measured by means of the type of apparatus illustrated in sketch B or similar.

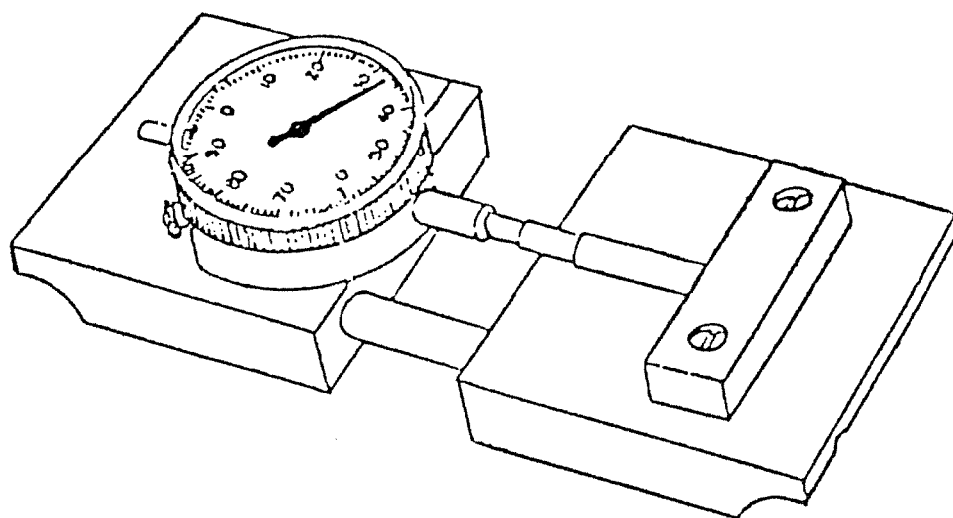
3.3 Flatness of Rail Seat

The flatness of the rail seat shall be measured by means of the type of apparatus illustrated in sketch C or similar.

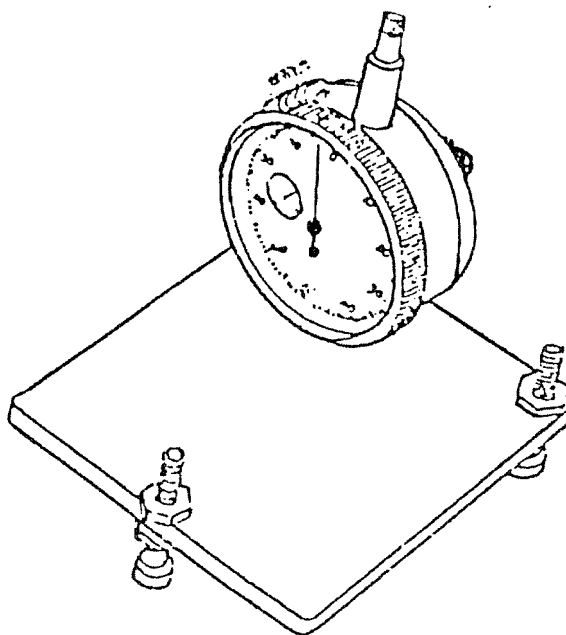
3.4 For each of the foregoing measurements the manufacturer shall make available similar or approved apparatus at his factory for the use of Spoornet's inspectors.



SKETCH A



SKETCH B



SKETCH C

Specification PWM 2/5 approved

A handwritten signature in black ink, appearing to read 'D.A. Barnard', with a long horizontal stroke extending to the right.

D.A. Barnard
Chief Engineer (Infrastructure)

Date:- 96/09/04