AN ALTERNATIVE TO TRADITIONAL TIMBER SLEEPERS ON TOURIST AND HERITAGE RAILWAYS

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Imagine a section of forest being destroyed and turned into timber sleepers which are then inserted into the ballast and having a lifespan of only ten to fifteen years. Another section of forest is then targeted for the replacement of the deteriorated timber sleepers. This timber refreshing cycle will continue until a cost effective and environmentally friendly alternative can be found to replace timber. For many years, Tourist and Heritage railway operations in Victoria were adopting this timber refreshing cycle by using second-hand timber sleepers due to their low capital cost. However, nowadays, the quality and quantity of second-hand timber sleepers is declining which imposes relatively heavy demand with the maintenance of these sleepers to keep the tracks going. Purely relying on volunteers, the resulting maintenance duty is difficult to sustain.

Plastic and composite sleeper technology has been available for more than 20 years and the trend towards increased usage of alternative sleepers is growing throughout the world due to their advantages in both economical effectiveness and environmental sustainability. Many suppliers now manufacture a range of plastic-composite sleepers which are used as alternatives to traditional timber, steel and concrete sleepers and claim that they are extremely durable, comparably strong and have low maintenance requirements, yielding significantly lower total lifetime cost. Typically, when compared with timber sleepers, these alternative sleepers claim to achieve a lifespan more than threefold that of comparable timber products. Furthermore, several types of composite sleepers are manufactured entirely or partially from recycled plastics and waste, and as a result, they are more environmentally savvy and friendly. These features of plastic-composite sleepers make them particularly attractive to Tourist and Heritage railways.

To support the Tourist and Heritage railway industry in assessing the benefits of plastic-composite sleepers in a local setting, Public Transport Victoria (PTV) collaborated with the Institute of Railway Technology at Monash University to develop Victorian standards for plastic composite sleepers. Even though alternative sleepers are achieving a foothold across the world, a major issue within Australia is that no standard or code exists for the use of these products. Only recently, the American Railway Engineering and Maintenance-of-Way Association (AREMA) have put together a specification for their use in the United States (Chapter 30, Part 5: Engineering Composite Ties) and the International Organisation for Standardisation (ISO) has just started to develop the international standard for plastic railway sleepers (ISO-12856). The ISO-12856-1 for material characteristics was published in 2014, but ISO-12856-2 for Products Testing is still under development. Queensland Rail has also recently developed a specification to support their tender which invites plastic-composite sleeper manufacturers to supply trial sleepers, but the specification is only an internal document and the track conditions stated are not applicable to Tourist and Heritage railways. The lack of corresponding national and international standards has created difficulties for both suppliers and purchasers to seek general guidance in terms of acceptance criteria for product testing and qualification in the Australian environment. For this reason, the Tourist and Heritage sector as a whole, together with their registrar within PTV, engaged the IRT at Monash University to prepare guidelines for the design and testing of plastic sleepers to determine the minimum requirements for plastic-composite sleepers to be used in Tourist and Heritage operations. The guidelines provide a baseline series of laboratory tests which can be used to ensure that a new plastic sleeper product can meet a minimum 'fit for purpose' standard before being put into service.

Above: Completed pedestrian crossing at Wooralla Drive on the Mornington Railway. Sun.12.11 *Stephen McLachlan*

Left: Installing the composite sleepers at the Wooralla Drive pedestrian crossing. Sun.17.9 *Integrated Recycling*

The properties of a plastic-composite sleeper can vary significantly depending on its geometry, manufacturing method and material composition. The performance of the sleeper must be considered in the context of its application. In a railway application, the product will be faced with constant exposure to the environment, chemicals (both natural and man-made), significant variation in ambient temperature and applied load due to wheel passes and track maintenance. To fulfil the expectation of manufacturers, suppliers and purchasers, it is anticipated that a plastic-composite sleeper must be capable of withstanding these environmental and service impacts as well as sustaining its material integrity for a service life of approximately 50 years. In order to completely reflect these expected requirements, the testing regime covers the assessments of physical properties, mechanical properties and tailored tests to simulate in-track loading of plastic-composite sleeper products.

In order to assess the age and ongoing condition of the plastic-composite sleepers over their lifecycle, the guidelines stipulate the requirements of identification to ensure the traceability of individual sleepers. The minimum requirement is indelible marking of every sleeper with an identification number which can be either serial or batch number or the combination of both. The adoption of GS1 standards for marking and identifying considered by the railway industry from 1 January 2019 may be appropriate to consider to meet this requirement. The guidelines also include a range of specified manufacturing tolerances. The main purpose of this requirement is to ensure the consistency of the manufactured sleepers in terms of straightness, dimensions, flatness, rail seat cant and density. These parameters can also be utilised in the quality control process during manufacturing. Sleeper density was a primary variable assessed, with low variability targets specified to ensure the uniformity of the product. It is important that density does not vary significantly from the tested product as this may significantly affect its ongoing performance. It is also stipulated the plastic-composite sleepers should be stable or inert to the environmental exposures, including chemical sources (herbicides, pesticides, fuels, lubricants, standing water, etc), temperature fluctuation, fire and UV radiation, throughout their service life. Additionally, the handling of the sleeper, inhaling dust or smoke should the product be burned, should not pose a toxic hazard to people or the environment.

The core component of the guidelines is to provide the required mechanical tests to critically evaluate whether the plastic-composite sleepers can functionally replace the timber sleepers. A series of laboratory-based tests are proposed to comprehensively assess the plastic-composite sleeper and rail fastening system as a whole. These tests include:

1 ELECTRICAL TEST

Electrical Test to assess the capability of the sleeper system to provide adequate electrical insulation for use in circuited tracks in both dry and wet conditions. The test is carried out by applying a constant AC voltage between assembled rails for a period of time and reporting the electrical resistances under dry and wet conditions.

Both images: Electrical testing assembly.
Institute of Railway Technology

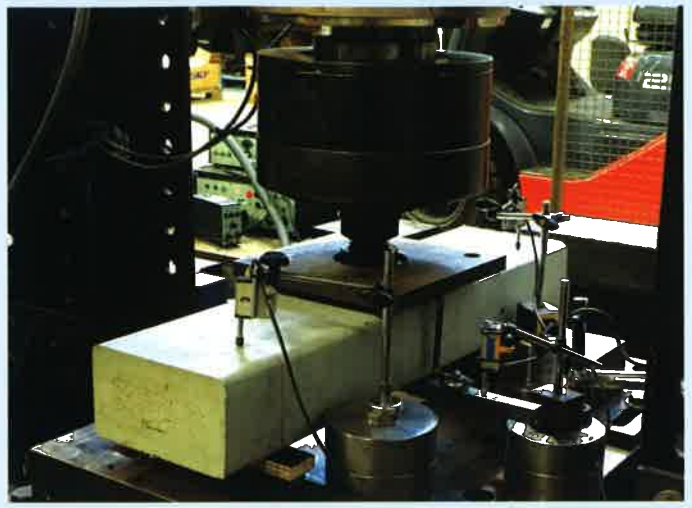
2 FASTENER PULL-OUT TEST

Fastener Pull-out Test to ensure that the fastening system used to secure either the rail or baseplate to the sleeper has adequate strength to maintain an appropriate clamping force once installed. The installed spikes are withdrawn using a testing fixture locking around the head of the insert, with the applied load being continuously recorded.

An example of the pull-out test. *Institute of Railway Technology*

3 BENDING MOMENT CAPACITY TEST

Bending Moment Capacity Test to ensure that there is sufficient strength in the manufactured sleeper such that it will not break or deform excessively under load during service. The test is carried out by applying a load related to the maximum design bending moment to the centre of the sample. Overloading to 150 per cent of the design load was then applied to provide a minimum factor of safety. If no fracture occurred, the specimen was reloaded until failure.



An example of the bending moment capacity test. *Institute of Railway Technology*

4 FASTENER REPEATED LOAD TEST

Fastener Repeated Load Test to ensure that the fastening system in combination with the sleeper material is capable of resisting the repetitive vertical and lateral loads during service. Based on the typical service conditions and fastening configurations in Tourist and Heritage operations, the required load and testing conditions are calculated. Compressive loading is then cycled between the required loads (calculated according to different loading cases in Tourist and Heritage networks). A minimum of three million cycles is required to successfully complete the test. This test is particularly important where sleepers are to be used in tight radius curves (particularly the case in Tourist and Heritage railways) as it provides confidence in the fastening system to limit lateral rail movement.

Both images: A typical set-up of the fastener repeated load test. *Institute of Railway Technology*

5 RAIL SEAT DURABILITY TEST

Rail Seat Durability Test to measure whether the manufactured sleeper is capable of withstanding cyclic bending moments during service. The test assembly is the same as that shown in the Bending Moment Capacity Test. Compressive loading is cycled between the required loads. The required loads were computed to reflect the bending moments required in different loading cases in Tourist and Heritage railways.

6 SLEEPER LATERAL STABILITY TEST

Sleeper Lateral Stability Test is designed to compare alternative sleepers against traditionally-used timber sleepers. The test involves consolidating the panel comprising three sleepers into the ballast by applying cyclic loading. At completion of consolidation, crib and shoulder ballast was built around sleepers. The lateral resistance test was then conducted by pulling the panel sideways. Throughout testing both the applied load and displacement are logged.

Sleeper Lateral Stability Test assembly. *Institute of Railway Technology*

Through the support of Public Transport Victoria, the Institute of Railway Technology has now successfully tested several alternative sleeper products against the guidelines outlined in this article. Product trials are now starting on the Tourist and Heritage railway networks.

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References

AREMA – *Manual for Railway Engineering*, American Railway Engineering and Maintenances of Way Association, 2016.

Plastics, plastic railway sleepers for railway applications (railroad ties), Part 1: Material characteristics. ISO 12856-1:2014: International Organization for Standardization, 2014.

Material supply specification: Alternative sleepers. TRACK-CT172, Revision: A: Queensland Rail Limited, 2015.

La'Brooy A, Tew G, Cookson J, Qiu C. 'Guidelines for design and testing of plastic sleepers for tourist and heritage railways Victoria'. Institute of Railway Technology, Monash University, 2015.

Right: An Up service to Mooroodurc Station traverses the section of track upgraded with the new composite sleepers. Sun.12.11 *Stephen McLachlan*

Below: Three-inch composite sleepers were installed on a gentle curve on the Puffing Billy Railway at Belgrave. Sat.24.6 *Integrated Recycling*