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11TH HARDWOOD CONFERENCE PROCEEDINGS

Róbert Németh, Christian Hansmann, Holger Militz, Miklós Bak, Mátyás Báder

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Possible alternative to creosote treated railway sleepers, Fürstenberg-System Sleeper (FSS)

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ABSTRACT

High-quality railway sleepers are capable of withstanding environmental impacts such as weather conditions and the attack by wood destroying organisms, providing long service life. However, poor-quality railway sleepers, due to their shorter lifespan, can lead to early failures and jeopardize safe railway traffic. Creosote, applied to enhance durability, is harmful to the environment and human health. Research worldwide seeks alternatives, emerging not only from new preservatives but also from manufacturing technology. One possible solution is the application of Fürstenberg-System Sleeper®, offering alternatives to currently used sleepers, from machining processes that promote drying, to new wood preservatives, to species-specific impregnation processes.

INTRODUCTION

Railway sleepers continue to be used worldwide in track construction for standard tracks, switches, bridges, light railways, and tunnels. Due to favorable vibration and noise characteristics, they are suitable for train speeds below 160 km/h. They are easily machinable and can be adapted to unique track gauges. They are advantageous for sharp curves in mountain railways. Their low weight facilitates transportation and movement even without machinery in underground track construction. Environmentally friendly oak bridge sleepers can be used without preservative treatment. Compared to concrete sleepers, wooden sleepers have advantages in bending, compression, and flexibility but are susceptible to biotic damage. In extremely cold climates, the use of concrete sleepers is not possible as frozen moisture in cracks leads to deterioration of the base. The lifespan of wooden sleepers in railway tracks can be increased by 3-6 times following treatment with preservatives, with a maximum lifespan of about 30 years or more.

Generally untreated wooden sleepers undergo an itemized inspection, thus each sleeper to be treated with a wood preservative and or being installed undergoes individual examination. The quality requirements of untreated wooden sleepers are specified in the European standard EN 13145:2001+A1:2012. The standard describes various quality characteristics, permissible wood defects, wood species, manufacturing parameters, shapes, dimensions, tolerances, as well as durability and preservative treatment criteria. In Hungary, the certification is carried out by a testing organization accredited for this standard, involving approximately 15-18.000 standard sleepers and 1500-2000 m³ of switch sleepers annually.

Saturation can only be carried out on properly prepared sleepers, primarily regarding moisture content. If the wood cells are saturated with water, the preservative cannot penetrate, so the wood must be dried beforehand. The speed of drying also matters, as too rapid drying leads to various deformations and large cracks.

Prolonged natural drying, depending on weather conditions, allows for the colonization of decay fungi. Cracking is a natural consequence of drying. If this is not visible on the wood, it is likely that its moisture content is still too high. Cracks can develop for various reasons, whether as a result of drying or due to frost. Determining how these cracks formed and how they affect the strength and lifespan of the sleeper to be installed must be decided by a trained inspector for each individual piece.

In recent decades, the environmental and human health impacts of treating railway sleepers have come to the forefront. Creosote, the traditional wood preservative for railway sleepers, has been classified as a biocide in Europe, and its use was permitted for only a few years starting from 2016, with multiple extensions granted thereafter. The most recent extension occurred in 2022 (European Commission Regulation 2022/1950), permitting the use of creosote - albeit with restrictions and only in certain member states - until October 31, 2029.
Due to the importance of environmental and human health considerations, the long-term use of creosote is ruled out. Therefore, railway sleeper manufacturers are collaborating with scientific research institutes and universities to find alternatives to creosote, while retaining all the benefits it provides:

- Improving and maintaining the wood's resistance to biological attack over the long term,
- Hydrophobizing the surface of sleepers,
- Preserving the long-term flexibility of railway sleepers,
- Multiplying the service life of the wood.

Fürstenberg-System Sleeper®

The Fürstenberg-System Sleepers®, have more than a decade of application experience and have been installed in over half a million units across the European rail network (Figure 1).
The key components of the system are:

- New in Europe mechanical pre-treatment through incising perforation.
- The use of alternative oil-based wood preservatives.
- Wood species-specific impregnation process:
    a. Single impregnation for oak.
    b. Double impregnation for beech and pine species.

Figure 1: Advantages of Fürstenberg-System Sleepers® 1, Sleepers in their raw state: sustainable raw material, CO2-neutral, positive impact on ecological balance 2, Saturation: Tar-free, approved under the European biocide products regulation, environmental and occupational health benefits 3, After treatment, it has minimal odor and is 100% recyclable (fuerstenberg-thp.de)

Overview of Fürstenberg-System Sleeper® Technology

Mechanical pre-treatment

Mechanical pre-treatment (incising) of sleepers is carried out before drying and impregnation (Figure 2). All four longitudinal surfaces of the sleepers are machined, creating perpendicular surfaces to the grain direction, which facilitate more uniform removal of free and bound water along the entire length of the sleepers.

- Facilitates faster and more uniform drying
- Reduces drying cracks, resulting in fewer long, deep cracks

As a result of machining, the sleeper dries more uniformly and quickly, resulting in fewer large and long, quality-degrading deep cracks on the surface, thereby reducing drying losses and ensuring more uniform distribution of internal stress in the inner layers of the wood.

- Facilitates greater penetration of preservatives
- Optimizes and ensures more uniform application of preservatives for long-lasting protection

Treatment with alternative oil-based wood preservatives

- Use of alternative oils as the base for wood preservatives

SleeperProtect®, an alternative oil-based wood preservative, specifically developed for treating railway sleepers, is water-free. To ensure biological efficacy, it contains copper-based and organic

agents. This combination has been proven effective in wood protection for decades. The alternative oils serve as carriers for the active ingredients and also exhibit very effective water-repellent properties. Additionally, they provide greater flexibility to the impregnated sleepers. After treatment, the oils dry and solidify, creating a dry surface that facilitates handling.

- Water-repellent properties contribute to maintaining the flexibility of wooden sleepers for many years
- Free from tar oils and their constituents
- All active ingredients meet the requirements of the European biocide products regulation
- Minimal odor

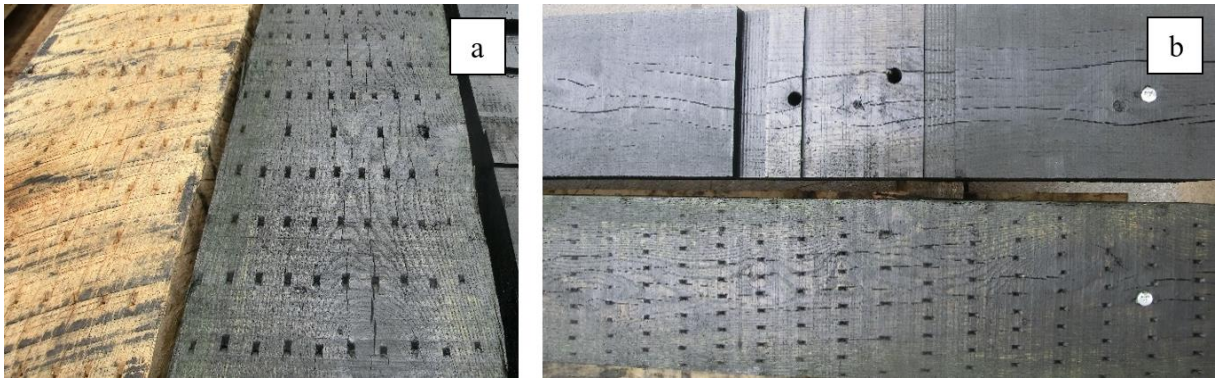

Figure 2: Image of mechanical machining before and after impregnation (a), and as a result of incising, fewer deep longitudinal cracks develop on the surface of the sleepers (b)

After mechanical machining and achieving the appropriate moisture content, the sleepers undergo treatment with wood preservatives (Figure 3). The impregnation process is controlled in a computer-controlled impregnation plant, where the appropriate protection of the sleepers is achieved through an optimized impregnation process tailored to the wood species and preservative. The impregnation plant enablesempty and full cell processes , where predetermined vacuum and pressure cycles are fully controlled by the computer. This includes temperature regulation during the process, as well as control over various process parameters and preservative intake. The computer performs the setting of appropriate parameters and continuous monitoring according to pre-programmed impregnation and process protocols.

For the Fürstenberg-System Sleeper®, the impregnation technology is specialized for each wood species to achieve the most effective protection. For oak wood species, the Protect OS-320 B (SleeperProtect®) wood preservative from Koppers is used. For beech and pine wood species, a double impregnation process is used for adequate protection:

- Initially, the sleepers are impregnated with water-based wood preservatives, typically using Korazit KS or Wolmanit CX wood preservatives.
- In the second step, once the wood has reached its saturable moisture content, impregnation with Protect OS-320 B preservative is also carried out.

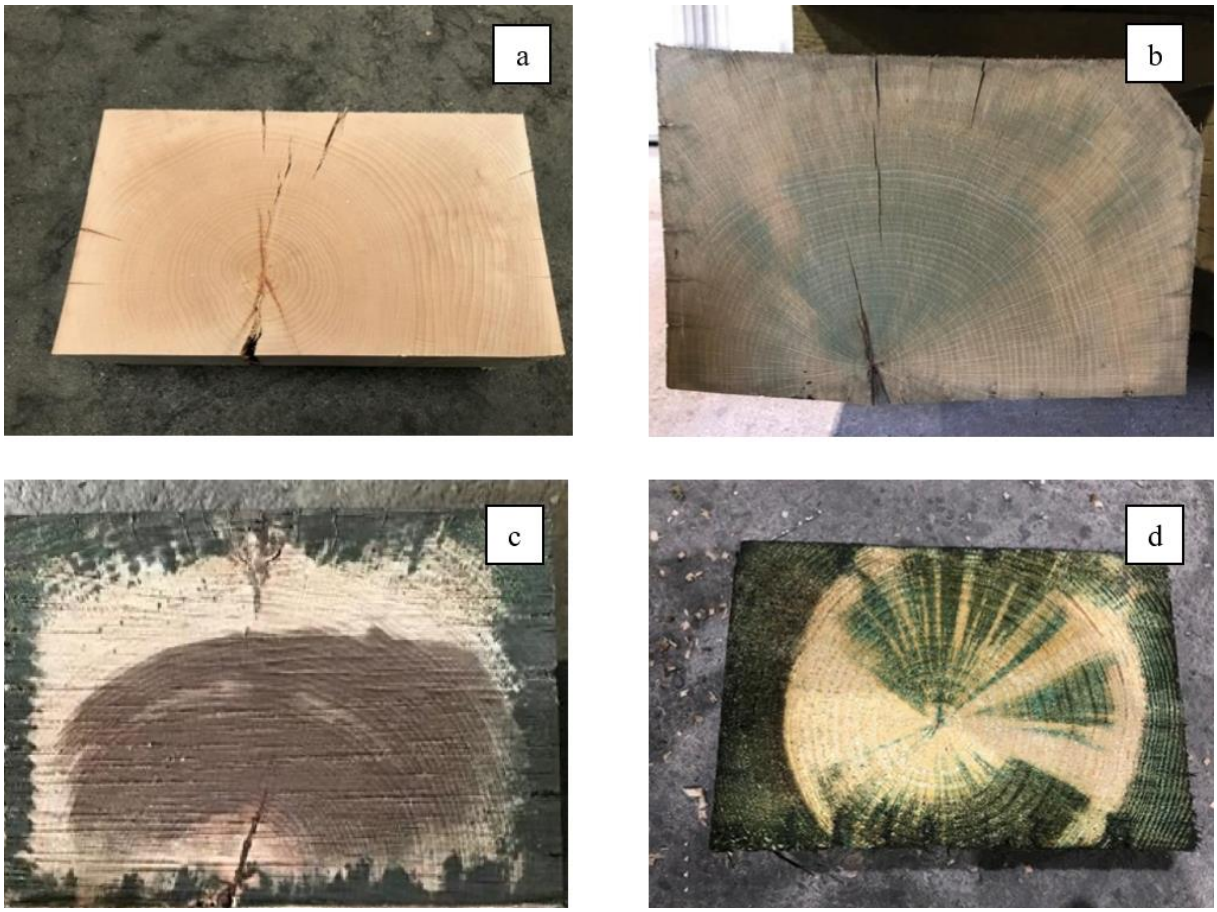

Figure 3: Cross-section of beech sleeper before saturation (a), Cross-section of fully saturated beech sleeper with water-based preservative (b), Image of saturated area after second saturation with SleeperProtect (beech, dark green area) (c), Image of saturated area after second saturation with SleeperProtect (Scots pine, dark green area) (d)

The possible reuse of Fürstenberg-System Sleepers® railway sleepers

The secondary use of railway sleepers impregnated with creosote is severely restricted due to the biocide agents contained within them. Any residential reuse of removed sleepers from the track has been prohibited for decades. Working with them without protective gear is prohibited, as both skin contact and inhalation of the emitted substances are highly hazardous to health. According to the latest regulations, users must ensure that no creosote or creosote-saturated residues enter bodies of water or soil, and they must also ensure that the public cannot access creosote-saturated sleepers under any circumstances. Practically, sleepers removed from the track can only be disposed of/incinerated in specially designed power plants.

In contrast, after refurbishment, the Fürstenberg-System Sleeper® can be reintegrated into lower-grade tracks (private railways, industrial sidings), and they can also be used for energy purposes and private use (e.g., garden paths, landscaping elements, agricultural posts, etc.) - of course, in accordance with other applicable regulations in the given country.

CONCLUSIONS

The elements of railway track superstructure include sleepers, crossing sleepers, and bridge beams. From safety and economic perspectives, the goal is to install suitable quality bearers and keep them on the track for as long as possible. In recent decades, the increasing emphasis on ecological, environmental, and health considerations, along with the expected complete ban on creosote use, has brought alternative solutions to the forefront. The Fürstenberg-System Sleeper® is an alternative to creosote-treated sleepers, ensuring continued use of wooden sleepers in railway construction even with the ban on creosote use. The system has been registered with the European Patent Office (EPO 17169384.9), ensuring that the quality of every sold FSS sleeper remains consistently high.

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