

Railway Track Construction with Eslon Neo Lumber FFU Synthetic Wood
Translation of Article announced in "Eisenbahningenieur-04/08"

Railway Track Construction with Eslon Neo Lumber FFU Synthetic Wood

Optimum overall economic efficiency for open steel structures, switches on ballast tracks, slab tracks, as well as for special rail-related infrastructure projects.



Fig. 1: FFU synthetic wood at Tokyo Station

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Chemicals and plastics specialists of the SEKISUI group of Japan developed Eslon Neo Lumber FFU (Fiber Reinforced Foamed Urethane) with the goal of producing a synthetic wood, featuring the same advantages for track construction as natural wood. The product was designed to offer the same material properties which provide the simple handling and finishing of wooden sleepers (fig.1). For instance, approx. the same specific weight as natural wood, it was intended for a considerably longer lifespan and increased weathering resistance. Statistical records of Japanese railroad operating companies gave evidence that around 70% of natural wood sleepers needed replacement due to decay (rotting, decomposition).

In 1978, Sekisui received an award bestowed by the General Director of the Research and Development Agency of Japan, as well as the Okochi Memorial Grand Technology Prize and the Deming Prize for comprehensive and first class corporate quality control. In 1980, two test tracks were equipped with Eslon Neo Lumber FFU in cooperation with the Railway Technical Research Institute and Japan's National Railway. In the Kanmon tunnel on the Sanyo main lines (on the stretch between km 531+680 and km 531+700) 74 monoblock synthetic-wood sleepers were installed on a slab track. On the Uetsu line

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18 synthetic-wood bridge sleepers were used on the track of the Miomote River Bridge (on the stretch between km61+294 and km61+316).

After a 5-year field-test, which demonstrated excellent performance and compliance with all guidelines and requirements, Eslon Neo Lumber FFU became a standard product used by Japan's National Railway since 1985, especially in the construction of steel structures, switches, tunnels, and both ballast-bed and slab track sections.

In 1996, the Railway Technical Research Institute removed synthetic wood from the first test tracks and subjected them to further testing. In the course of this process, load cycle tests were conducted, which showed that the durability of synthetic-wood sleepers exceeds 50 years. (fig.2)

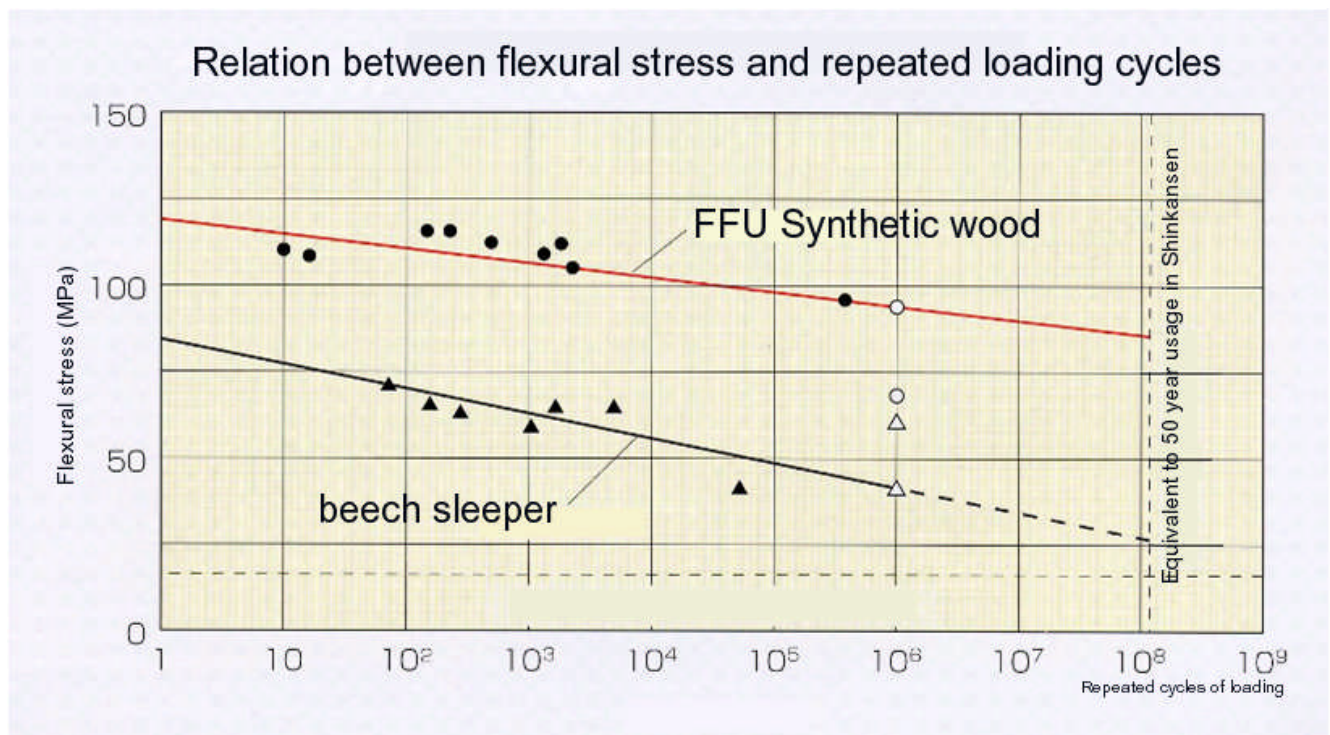


Fig. 2: Eslon Neo Lumber FFU synthetic wood life cycle

In 2004, FFU synthetic wood was put to use for the first time in Europe. Based on the technological collaboration with KOMAT GmbH, Vienna's public transit operator Wiener Linien opted for the use of Eslon Neo Lumber FFU as bridge sleepers for an open steel structure in Vienna. To date, FFU synthetic wood has been deployed at further bridge projects undertaken by Wiener Linien (fig.3). From 2005 on, Austria's National Railways (Österreichische Bundesbahnen - ÖBB) have deployed Eslon Neo Lumber FFU on several projects across the national railway infrastructure (fig.4).

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Fig. 3: FFU synthetic wood, Zollamt Bridge built by Wiener Linien, Vienna, Austria

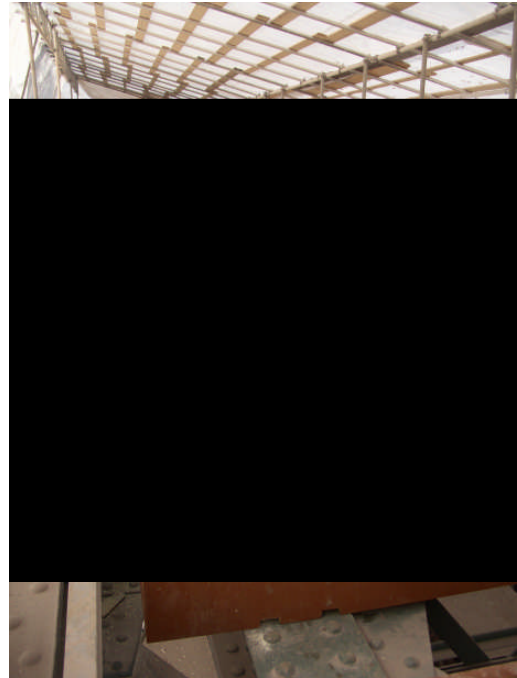


Fig. 4: FFU synthetic wood, Karwendel Bridge built by ÖBB Innsbruck, Austria

Custom-Made Synthetic Wood Products

How is Eslon Neo Lumber FFU for track construction produced? At the beginning of the production line, individual glass fiber strands are tied into a bundle of unidirectional glass fibers and run through a high-pressure pultrusion press, where they are cast in polyurethane. After leaving the production plant, the non-porous, newly-molded glass-fiber-polyurethane composites are cut to the standard length of 12m and stacked for further processing.

ESLON-NEO Lumber FFU synthetic-wood in its base form, featuring endless directional glass fibres as a suitable basis for rail construction, is now ready for further processing. According to the specifications of the contracting railroad operator, SEKISUI produces synthetic wood sleepers and bridge sleepers with precise millimeter accuracy.

Customers, however, are offered the option of prefabrication at the production site.

Provided that standard dimensions do not apply, the production of synthetic wood products is always conducted in accordance with authorized blueprints, Dimensions of synthetic wood products can be optimized based on deviating forces and on-site geometric boundary conditions. So far, FFU synthetic wood switch sleepers with lengths of up to 9.6 m were delivered, as well as synthetic FFU bridge sleepers with a cross-section of 300/300/3500 mm for open steel structures with longitudinal girder intervals of 2.5m to ensure compliance with permissible deformations during daily railway

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operations. Furthermore, special cross sections with a reduced height of 100mm were installed for Wiener Linien (fig.5).



Fig. 5: FFU synthetic wood 100 mm strength, Floridsdorf Bridge, Vienna,



Fig. 6: FFU synthetic wood with double layer packing

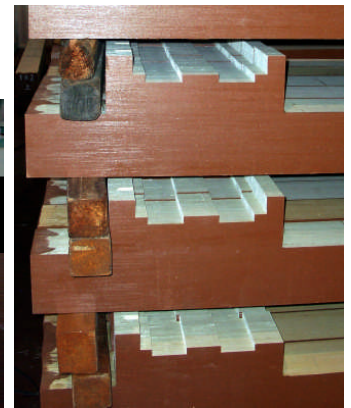


Fig. 7: FFU synthetic wood, recessed bearing surface

Furthermore, ex-works production may include the option of required cants in the shape of false edges. (fig.6) Upon request, pre-manufacturing may include details such as rivet heads, reinforcement of upper flanges (fig.7), milled recesses for rail fastenings, surface sanding, various surface features, notches, and slots. When manufactured in accordance with authorized blueprints, custom-made elements can be delivered directly to construction sites (fig.8). At the production plant, every single piece of synthetic wood is clearly labeled according to the blueprints and subsequently installed in the correct location on-site.

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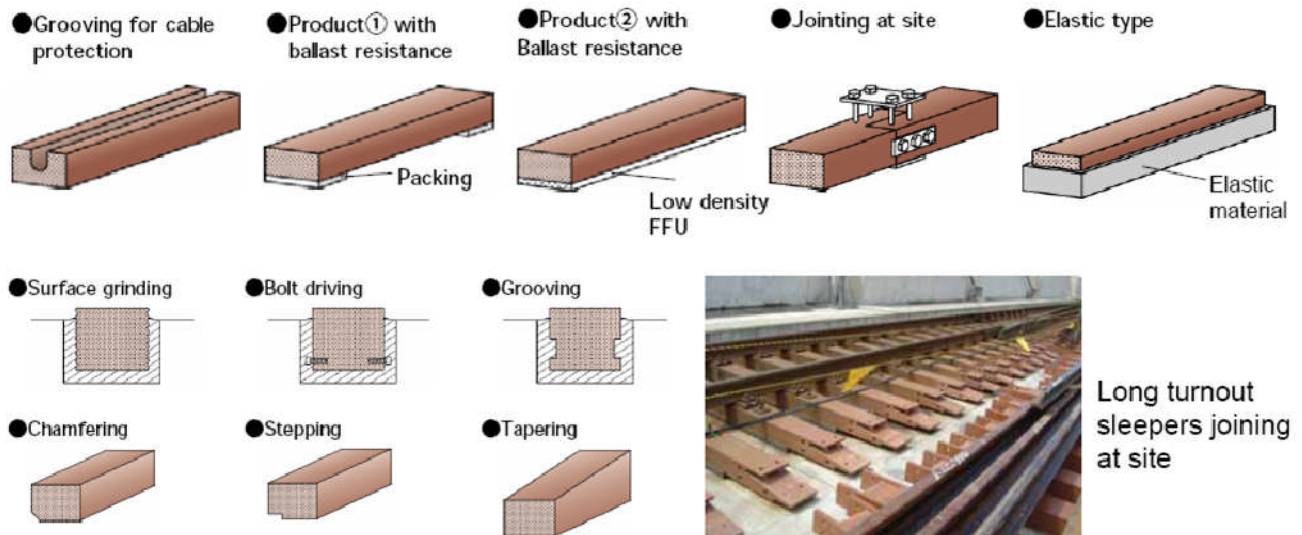


Fig. 8: Production and typical fields of application for FFU synthetic wood for track construction (SEKISUI)

Eslon Neo Lumber FFU for track construction was subjected to a large number of laboratory tests at Sekisui group and independent testing institutes. These tests showed synthetic wood FFU74 to have a specific weight of 740kg/m³, flexural strength of 142MPa, modulus of elasticity of 8.100MPa, compressive strength of 58MPa, insulation resistance (dry) of 1,6x10¹³Ω, and a pull-out force for sleeper bolts of 65kN. Moreover, tests regarding fatigue strength, reaction to fire and temperature were conducted, as well as situations for special projects, (reconstructed in a 1:1 scale model), plus objective assessments by accredited testing institutes in order to meet customer requirements.

What about the utilization of Eslon Neo Lumber FFU after its life cycle has come to an end? When after more than 50 years, the synthetic wood needs replacement, it is completely recyclable. Synthetic wood may be reprocessed and reused in products not subjected to heavy strain. Eslon Neo Lumber FFU offers a closed material cycle and thus, meets current ecological and economic demands

On Site Processing of Synthetic Wood Sleepers

Drill holes for the anchoring of rail fastenings by means of sleeper bolts are carried out with commercial-grade drilling equipment. Likewise, there is no difference to natural wood when it comes to cutting, trimming, milling out or off, and chiseling. Due to the high amount of glass fiber contained in this material, however, the use of high-grade tools (drill, saw blade) has become the established method (fig.9).

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It goes without saying that just as with natural wood, all applicable rules and regulations must be followed when working with synthetic wood.

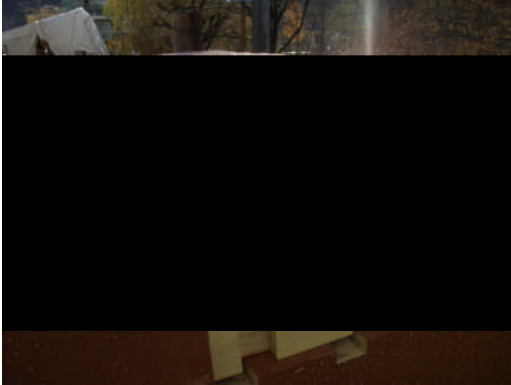


Fig. 9: FFU synthetic wood cut to size on site

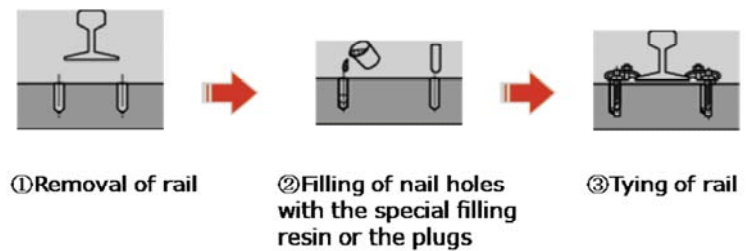


Fig. 10: Eslon Neo Lumber FFU synthetic wood repair methods

Ever since SEKISUI developed the method of replicating the fibril structure of natural wood, Eslon Neo Lumber FFU synthetic wood no longer features the porosities of its natural counterpart. Therefore, this highly homogenous high-grade material absorbs no water. When pre-drilling fastening holes, for instance for sleeper screws, the non-porous homogeneity of the material requires the observation of correct drill hole diameters.

During the course of construction work, the actual on-site situation can change, deviating from the original plan, so that drill holes may end up in the wrong place, or the synthetic wood may be needed for other uses. This problem can be solved through two fundamentally different but extremely simple repair methods. The first is the quick solution, in which a wrongly-positioned drill hole is filled with urethane resin and an Eslon Neo Lumber FFU dowel is subsequently driven into it. After 20 minutes already, the new screw hole can be drilled in the right position, even at just a few millimeters distance from the center of the previously repaired one. The second solution is to fill the wrongly positioned drill hole with epoxy resin. After a 4 hour hardening period, the new hole can be drilled in the correct position, even in the area of the repaired drill hole (fig.10). Rail fastenings can now be installed, and sleeper bolts can be screwed in with a defined moment of torque.

Projects Realized with Eslon Neo Lumber FFU

How many kilometers of tracks have been built using Eslon Neo Lumber FFU since 1985? In sum, bridge, switch, and tunnel projects in which synthetic wood has been used since 1985, amount to a track length of over 870km. In other words, over the last 20 years, an average of over 40 km of rails were built with Eslon Neo Lumber FFU per year. Synthetic wood has been deployed both in LRT systems with low axle loads, as well as in those with axle loads above 30t (fig.11).

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Esilon Neo Lumber FFU has been predominantly used in Japan on the Shinkansen high-speed railway network, as well as on regional railway and subway lines (fig.12 and fig. 13). In Taiwan, China, and Austria economically responsible rail infrastructure operators and maintenance organizations have increasingly opted for synthetic wood and its long-term advantages. There, it is mainly used in the areas of open steel structures and switches (fig.14).



Fig. 11: FFU synthetic wood, switches, at train depot, China



Fig. 12: Detail of rubber embedded FFU synthetic wood at slab track switch, Japan

Experience, Advantages, and Benefits

In comparison to natural wood, we are looking at an industrially produced synthetic wood that is manufactured systematically and delivered to order with precise millimeter accuracy. Esilon Neo Lumber FFU remains dimensionally stable after installation, and stays solidly put on the steel surface while retaining its homogenous structure. In ballast track areas, dovetails are used on sleeper undersides in just the same way as with natural wood. In order to facilitate the transfer of horizontal lateral forces in switch areas or on bottom side footing, FFU synthetic wood ledges, or lateral steel sheets can be added. Cants, recesses, and required form modifications are available prefabricated on request. Dimensional stability is guaranteed through quick and immediate on-site installation of synthetic wood elements on open steel structures and switches. Just as with natural wood, its weight ensures easy transport to construction sites and features many advantages, especially on existing steel structures. The material shows a homogeneous and unequivocal distribution of load diverting forces (bundles of unidirectional glass fiber). In case of substructure replacement, the good performance characteristics of synthetic wood allow for the minimizing of its cross-section dimension in order to meet requirements in areas where the top of the rail is not permanently defined. The material is non-porous and, therefore, does not absorb liquids. There is also no chemical reaction when it is brought into contact with the lubricants and chemicals that are used on a daily basis in railway operations. Simple repair routines and the use of common cutting and drilling tools can be derived from woodworking experience. Good

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transfer of forces and composite action between sleeper bolts and synthetic wood, high weathering resistance, and the material's sealed structure result in minimal maintenance work and -costs. If after more than 50 years a replacement of synthetic wood should be necessary, it can be returned to the plant and completely recycled. The initial investment in the construction of substructures using Eslon Neo Lumber FFU is slightly higher than the conventional use of natural wood. The durability of FFU synthetic wood in the above mentioned areas, however, is considerably higher than that of wood. Aside from its excellent technical characteristics, the resulting life cycle costs have contributed to the decision of railway operators to deploy synthetic wood in the areas described above. 20 years of experience have shown that the use of synthetic wood technology results in high availability of tracks and reduced maintenance costs. This is what economically minded railway operators, who have opted for Eslon Neo Lumber FFU, like about it.



Fig. 13: FFU synthetic wood, soft slab track switch, Japan



Fig. 14: FFU synthetic wood bridge sleepers on open steel structure, Japan

Summary

Esilon Neo Lumber FFU for track construction was developed in 1978. Since 1985, it is a standardized product used predominantly in Japan's railway infrastructure. Here, it has been applied on the Shinkansen high-speed rail link, on regional railway lines, and urban subways. It is predominantly used in the areas around switches, open steel structures, and tunnels. FFU synthetic wood is used both on ballast and slab tracks. In 2004, the first project using FFU synthetic wood in Europe was realized by Wiener Linien in Vienna. Subsequently, several projects were launched in Europe. This synthetic wood consists of unidirectional continuous glass fiber bundles cast in non-porous polyurethane, and may be processed in much the same way as natural wood. This homogeneous material extends service life in areas exposed to extreme stress such as open steel structures to more than 50 years. Its characteristic technical values outperform natural wood by far. To date, FFU synthetic wood has been deployed to full customer satisfaction in switch areas, steel bridges, tunnel tracks and both on ballasted and slab tracks, amounting to 870km of tracks.