SEKISUI Chemical Co., Ltd.

Since more than 60 years leading manufacturer of synthetic products
Worldwide more than 200 subsidiaries
Approx. 20,000 employees
Main business areas of SEKISUI

High Performance Plastics

Urban Infrastructure and Environmental

Housing
FFU synthetic sleeper: Continuous glass-fibre and Polyurethane

FFU sleepers are manufactured either by means of pultrusion or extrusion. Glass fibers are soaked in polyurethane and the linkage is then hardened at a raised temperature.

FFU has
- the **durability** of plastics
- the **light weight** and **workability** of wood.

Thermosetting Resin Foam (Rigid Urethane Resin)
FFU bridge sleepers

FFU short sleepers

FFU regular sleepers

FFU switch sleepers

18.04.2013
1980  Railway Technical Research Institute adopted FFU after laboratorial approval in Japan and started the following field tests:

Miomotegawa Bridge of Uetsu Line and Kanmon Tunnel of Sanyo Line

1985  very good results of field tests - FFU sleeper became a approved product of JNR

1989  FFU sleeper employment was fully established in Tokaido Shinkansen, as the train operational speed became 270 km/h.

1991  Railway Tech. Res. Inst. reported the results of 10 years field tests, which showed almost no deterioration. Application of FFU by private and municipal railways.

1996  Railway Tech. Res. Inst. Reported the results of 15 years field tests, which indicated that the strength deterioration of 15 year old wooden sleepers will be equal to the strength deterioration of 50 year old FFU sleepers.

**Graph:**

Relation between flexural stress and repeated loading cycles

- Equivalent to 50 year suffering in Shinkansen
- FFU synthetic wood
- Beech sleeper

**Equation:**

Flexural Stress (MPa) vs. Repeated cycles of loading
2004  First FFU Railway project in Europe, Metro bridge in Vienna
2005  ÖBB and Wiener Linien install FFU on further projects
2007  Japanese Industrial Standard JIS 1203 “Synthetic sleepers – made from FFU”
2008  Research report TU Munich # 2466 from September 19
      Approval of FFU railway sleepers by Serbian State Railways
      LCC Analysis of TU Graz on request of ÖBB for FFU sleepers on open steel bridges
      First switch on FFU in Germany – Chempark Leverkusen
      Wiener Linien starts exchanging program on Metro tracks for FFU
2009  Installation of first FFU bridge sleepers in Serbia
      LCC Analysis for switch sleepers by TU Graz on request of Wiener Linien
      Approval of FFU by EBA for German Railway Infrastructure
      Installation of first train junctions made of FFU in Austria by ÖBB
      Request for projects with FFU from Austria, Czech Republic, Denmark, Germany,
      Hungary, Lithuania, Poland, Russia, Serbia, Switzerland, Turkey
2010  Installation of FFU switch in Germany by Hamburger Hochbahn and MVV Munich
      Installation of FFU double slip on Vienna main station by ÖBB
2011  DB – Deutsche Bahn – installed first Bridge with FFU sleepers and low height
      sleepers in ballasted track
2012  DB – Deutsche Bahn – installed two switches with FFU sleepers and
      additional bridge
Approximately 90,000 FFU Synthetic Sleepers are installed annually.
Accumulated installation amount has become
more than **2,1 million sleepers** more than **1.300 km** of track (2012)
EBA (German Railway Authority), following research was conducted:

Sleeper behaviour under the impact of vertical and horizontal loads during the effect of repeated loading. Bedding in ballast track according DIN-EN 13481-3 (wooden sleeper)

Tightening torque tests: determine tensile strength of sleeper screws depending on torque moment.

Sleeper screw extraction tests in accordance with DIN EN 13481-2. (concrete sleeper)

Impact tests to simulate derailment in accordance with German railways technical terms of delivery

Electrical resistance in accordance with DIN EN 13146-5

Static and dynamic tests of sleepers according to DIN EN 13230-2.(concrete sleeper)

**Effect of repeated loading test**

<table>
<thead>
<tr>
<th>Elastic Rail Head Deflection</th>
<th>Constant Rail Head Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>right support</td>
<td>left support</td>
</tr>
<tr>
<td>2.12 mm</td>
<td>1.71 mm</td>
</tr>
</tbody>
</table>

After endurance test of 3 million load cycles
Extraction Testing

Average extraction force in FFU is **61 kN**.
Previous extraction tests on sleeper screws on wooden sleepers showed extraction forces of approx. **35 kN**.
[see Research Report no. 1687, dated June 30.,1997].

Impact Tests

A tup (5 kN) with a wheel-flange shaped blade is dropped twice per test from a height of 75 cm onto the impact area. The sleeper is positioned at a slope of 30°. During testing, the sleeper is placed on a 6mm pad.

Electrical Resistance

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_y$ [kΩ]</td>
<td>38.9</td>
<td>63.8</td>
<td>57.7</td>
</tr>
<tr>
<td>$Y$ [mS/m]</td>
<td>44.4</td>
<td>45.3</td>
<td>44.6</td>
</tr>
<tr>
<td>$K_y$</td>
<td>1.332</td>
<td>1.359</td>
<td>1.338</td>
</tr>
<tr>
<td>$R_{33}$ [kΩ]</td>
<td>51.8</td>
<td>86.7</td>
<td>77.2</td>
</tr>
<tr>
<td>Mean value $R_{33}$ [kΩ]</td>
<td><strong>71.9</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hence, it can be assumed that the required minimum resistance value of $R_{33} \geq 5 \text{kΩ}$ in accordance with DIN EN 13481-5 was achieved with great certainty.
Static Tests on Sleeper Centre

Bearing distance was 1.5 m, load plate width was 100 mm. The initial test force was set at 20 kN. Subsequently, the load was gradually increased by 5 kN, while sleeper deflection was registered by four dial indicator gauges.

Up to a load of **240 kN**, corresponding to a tensile bending strength of 74 N/mm² on the bottom of the sleeper, no crack was detected within the bending area where flexural tension was applied.

Same test (265 mm x 160 mm) was concurrently conducted with a beech sleeper (265 mm x 160 mm). According to the test results, the wooden sleeper failed at a load of **80 kN** within the bending area.
Sehr geehrte Damen und Herren,

auf Ihren o. a. Antrag, mit dem Sie die Zulassung zur Betriebserprobung von Eslon Neo Lumber FFU Kunstholzschwellen für den Gleisbau beantragen, ergeht folgender

BESCHEID:

I. Ich erteile die Zulassung zur Betriebserprobung für die Eslon Neo Lumber FFU74 Kunstholzschwellen für den Einsatz als Gleis- und Weichenschwellen.

Customized sleepers produced at the plant

according to the Client’s drawings, FFU will be manufactured at the plant thickness, width, length, profile, over-heights, drill holes and milling can be freely designed by the Client according to the needs of his project. Every sleeper will be mm-exact produced and marked. Long sleepers: longest installed turnout sleeper in Japan was 9,6 m long
Customized production of FFU

1.300 km of track since 1985
Easy repair

For example: Fastening position may be readjusted by filling nail holes

1. Removal of rail
2. Filling of nail holes with the special filling resin or the plugs
3. Tying of rail

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FFU synthetic sleeper– www.sekisui-railway-technology.com

1.300 km of track since 1985
Projects in Japan since 1985

Bridges – open steel constructions – concrete

1.300 km of track since 1985

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FFU synthetic sleeper– www.sekisui-railway-technology.com
Projects in Japan since 1985

Switches – ballasted track - slab track

1.300 km of track since 1985

FFU synthetic sleeper – www.sekisui-railway-technology.com

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Projects since 1985

Japan, Taiwan, China - switches – ballasted track - slab track

1.300 km of track since 1985
Projects since 1985

USA - Bridge – 38 t Axel load - 40 million tonnes the year

1.300 km of track since 1985

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FFU synthetic sleeper – www.sekisui-railway-technology.com
2004 first Project in Europe
Austria - Vienna - Zollamtsbrücke

FFU Bridge Sleepers  >  50 years
Steel Construction   >  50 years
Rails               >  30 years
Corrosion Protection>  30 years

1.300 km of track since 1985

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FFU synthetic sleeper– www.sekisui-railway-technology.com
Projects in Europe since 2004

1.300 km of track since 1985
Projects in Europe since 2004

First bridge project of DB – Deutsche Bahn - 2011

1.300 km of track since 1985
Projects in Europe since 2004

Low height sleeper on DB – Deutsche Bahn network -2011

1.300 km of track since 1985
Projects in Europe since 2004

Switches

1.300 km of track since 1985

- FFU synthetic sleeper - www.sekisui-railway-technology.com

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Projects in Europe since 2004
Switches – double slap – Austria - ÖBB

1.300 km of track since 1985
Projects in Europe since 2004

Switches – Germany – DB AG

1.300 km of track since 1985
Handling on site

1.300 km of track since 1985

FFU synthetic sleeper – www.sekisui-railwaytechnology.com
Contact with ballast

1.300 km of track since 1985
## FFU Advantages

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customized sleepers</td>
<td>mm exactly optimizing of design &amp; profile</td>
</tr>
<tr>
<td>Form retentive</td>
<td>always good bearing on construction</td>
</tr>
<tr>
<td>Easy &amp; fast installation</td>
<td>minimizes: installation costs / track lock time</td>
</tr>
<tr>
<td>Easy care/repair</td>
<td>minimizes: installation time/sleeper amount</td>
</tr>
<tr>
<td>Chemical/oil resistance</td>
<td>application in special areas</td>
</tr>
<tr>
<td>Ecological</td>
<td>100% recyclable</td>
</tr>
<tr>
<td>Maintenance</td>
<td>very little; minimizes maintenance costs/time</td>
</tr>
<tr>
<td>High availability of track</td>
<td>maximizing possible trains on the track</td>
</tr>
<tr>
<td>Workability/weight</td>
<td>like wood</td>
</tr>
<tr>
<td>Long life time</td>
<td>reduces total cost of track and saves money for further project investments</td>
</tr>
<tr>
<td>Removal of sleepers</td>
<td>FFU sleepers will be changed one time</td>
</tr>
<tr>
<td></td>
<td>Wooden sleepers up to more then 3 times</td>
</tr>
</tbody>
</table>

1.300 km of track since 1985