
FFU
GROUND
BREAKING

SEKISUI

1980 – 2020 FFU SYNTHETIC RAILWAY SLEEPER TECHNOLOGY

SEKISUI CHEMICAL CO., LTD.
A new frontier, a new lifestyles.

FOREWORD

We are delighted to publish the 40th Anniversary Photobook of our FFU Synthetic Railway Sleeper.

The base material of FFU Synthetic Railway Sleeper, Eslon Neo Lumber FFU™, was a plastic based product developed in SEKISUI CHEMICAL CO. LTD.'s Kyoto Research and Development Center and its production was started in Shiga-Ritto Plant in 1974, with a product concept of "totally new structural materials that combine the features of natural wood and plastic".

In the years that followed, SEKISUI explored extensive applications in the railway sleeper field in cooperation with the Railway Technical Research Institute of the Japanese National Railway at that time.

The very first chapter in the history of FFU Synthetic Railway Sleeper was the trial installation on the bridge over the Miomote River and in the Kanmon Tunnel owned at that time by the Japanese National Railway in 1980.

The follow-up survey conducted by the Railway Technical Research Institute after 10 years, 15 years and again 30 years of installation has demonstrated that FFU Synthetic Railway Sleepers show no problem in operation and have high durability. In the 30 year follow-up survey, the report concluded that "the sleepers after 30 years in service…are considered unlikely to present problems in service in the coming two decades." Therefore, we are confident that the designed product life of 50 years, which we aimed for during the initial product development, is being verified over time.

FFU Synthetic Railway Sleepers have been installed on the track not only of metro and passenger lines but also of freight lines, high speed lines (Shinkansen) and extra-high axle load lines in steel mills, mainly used for turnout areas and open deck bridges. As of today, it has been installed on more than 90 railways in Japan.

After 20 years of installation in Japan, overseas export began with the supply of products to the Taiwan High Speed Rail in 2003. Currently, our products have been used by railway operators in more than 30 countries in Europe, the United States, Oceania and Asia, and are contributing to upholding the safe and stable railway operations.

With 40 years of experience in the railway industry, now SEKISUI offers various product technologies alongside FFU Synthetic Railway Sleepers, including products such as FRP insulated fish plate, Calmmoon™ Rail (rail noise reduction product), Sound Proof Panel and concrete structure repair materials. We are aiming to contribute to the further development of the railway industry through our technologies and products.

In this book, 40 year development history of FFU Synthetic Railway Sleepers with their unprecedented durability and longevity are introduced with pictures from each country. We hope this book leads to further discussions about FFU Synthetic Railway Sleepers and more dialogue on the method of utilizing FFU technology.

In closing, we would like to express our sincere gratitude to all parties who have supported and cooperated in the publication of this book.

Takashi Oguchi
Division Manager
Performance Materials Division
Urban Infrastructure and Environmental Products Company
SEKISUI CHEMICAL CO., LTD.

Cross Section of FFU with Glass Fibers

CONTENT

2018 | Shin-Osaka Station | Tokaido Sanyo Shinkansen | JR Central

FFU MILESTONES

1980
First installation at JR track

1987
High Speed Lines (Shinkansen) in Japan

2003
Start exporting (Firstly to Taiwan HSR)

2004
Start exporting to Europe

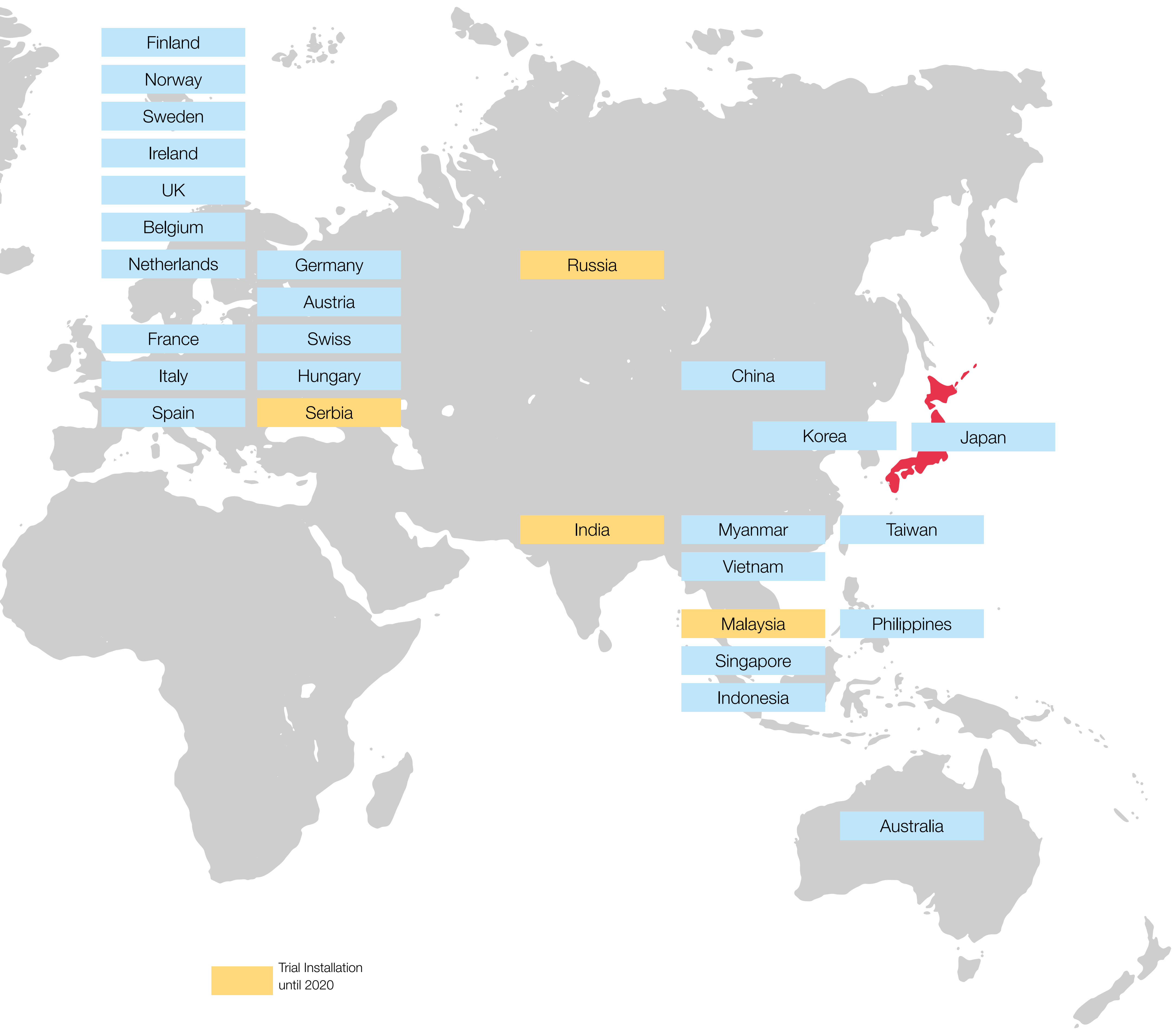
2011
Sleepers from 1980 removed and tested
by Railway Technical Research Institute Japan

2020
Installed in 32 countries all over the world

FFU INSTALLATION IN THE WORLD

32 Countries & Region including Japan

(Dec. 2020)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Korea
Japan
India
Myanmar
Taiwan
Vietnam
Malaysia
Philippines
Singapore
Indonesia
Australia
Trial Installation
until 2020

40 YEARS OF FFU
Synthetic Railway Sleepers

It began in Japan in 1980. Now 40 years on in 2020, nearly the whole railway world is placing its trust in FFU.

Dipl.-Ing. Dr. techn. Günther Koller

Part 1: Technology and Application

Fig. 1: Cross section of FFU synthetic sleeper showing amount of glass fibres

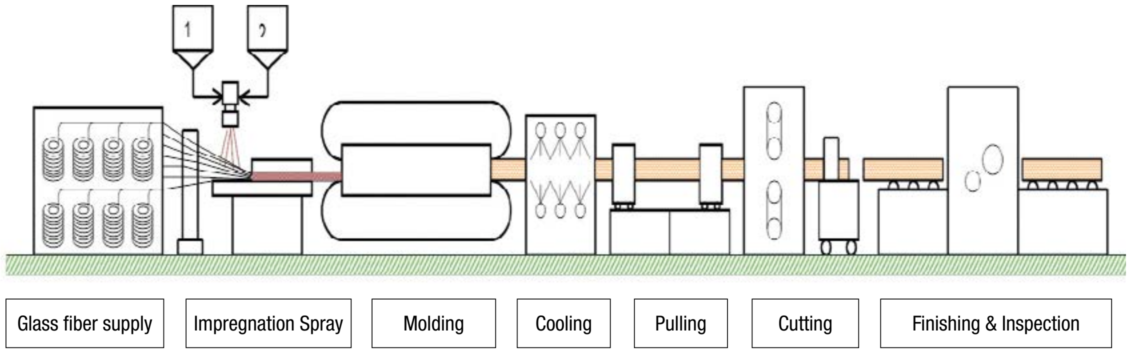

Fig. 2: FFU Synthetic Wood Railway Sleeper Manufacturing Process

Why Synthetic Railway Sleeper ?

In the 1970s, the Japanese Railway identified that the life expectancy of the wooden sleepers it was using were noticeably short, primarily because of it's exposure to the weather and the conditions around the sleepers caused by it.

As a result, the Japanese National Railways (JNR) wanted to create railway sleepers with the same material properties as the wooden sleepers. These would have to be unaffected by the effects of the weather in respect of their material properties and durability. SEKISUI, in partnership with JNR, developed a technology that would (Fig. 1). The development of this new sleeper, named Fiber-reinforced Foamed Urethane (FFU) Synthetic Railway Sleeper, was completed in 1978.

Production Process

FFU synthetic railway sleepers are produced by a pultrusion process (Fig. 2). In this, the base material of the sleeper is created by drawing the individual material components through a moulding casing.

Continuous surface-optimised glass fibres are drawn precisely into the moulding casing. A special polyurethane composite is added during the molding process. This saturates the very dense glass fibres completely and without porous. The precisely controlled heat temperature and the monitored molding speed enable SEKISUI to produce material with high quality and durability. The finished FFU strand is continuously extracted at the other end of the casing channel and monitored as it is cooled. It is then cut to the required length and checked again for its quality.

Customised Production

This technology enables SEKISUI to produce railway sleepers with unique shapes. This applies, for example, to sole plates from a height of as little as a few millimetres up to actually produced and installed sleepers of length 16 m, 70 cm width and 35 cm height.

Special productions depending on the project, cambers in curve areas, milled grooves for support bearings, holes and much more are precision pre-manufactured in the factory according to customer requirements. The sleepers are numbered according to the plan, stamped with the production period and delivered to the construction site for installation.

First Installation of FFU in 1980

The first FFU Synthetic Railway Sleepers were installed in two projects in 1980, in the form of field trials for JNR. One of these was a bridge with an exposed track and the other was a tunnel with bi-block sleepers in a slab track. FFU has been installed since 1985 as an approved regular sleeper in the Japanese railway network.

As of 2020, more than 2.55 million FFU railway sleepers have already been installed around the world. This is equivalent to a track length of more than 1,550 km. It should be remembered that FFU is primarily used in the areas of bridges and points (Fig. 3).

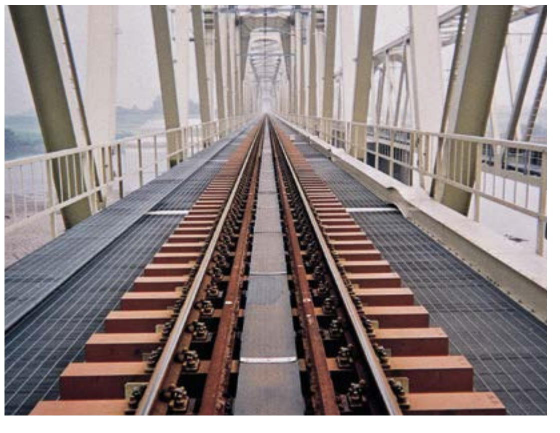

Fig.3: FFU-Bridge sleepers on the Tokyo-Osaka-Shinkansen High Speed Line (270 km/h)

Tested values		Unit	Value as equivalent of 740 kg/m³ density after 10, 15, 30 years in use and new sleeper				Requirement JIS New sleeper	Requirement ISO 12856-1 Type A New sleeper
			30 years	15 years	10 years	New		
Material strength	Flexural strength	N/mm²	116.6	131.4	114.6	142	≥70	≥ 60
	E-Modulus	N/mm²	8,414	8,788	8,044	8,100	≥ 6,000	≥ 6,000
	Compressive strength longitudinal	N/mm²	60.3	63.2	75.7	58.0	≥ 40	≥ 40
Electrical values	AC failure voltage	kV	≥ 25	≥ 25	≥ 25	≥ 25	≥ 20	≥ 20
	Insulation resistance	MΩ	8.2×10^5	1.4×10^6	1.1×10^6	1.6×10^7	$\geq 1 \times 10^4$	$\geq 1 \times 10^4$

Fig.4: RTRI Test values for FFU Synthetic Railway Sleeper new, after 10, 15 and 30 years in use. the values are the material failure values [1].

Tests by the RTRI – Life Expectancy 50 Years

The Japanese Railway Technical Research Institute [RTRI] tested FFU synthetic sleepers before their first installation in 1980, and again after 5 years, 10 years, 15 years and 30 years.

These tests served to investigate and document the long-term properties of FFU synthetic wood sleepers in daily railway operation.

The results of the tests after 30 years (2011) prompted RTRI to confirm in a letter to Japan Railway (JR) that the FFU synthetic wood sleepers could be used safely for the next 20 years, thereby confirming the forecast 50-year expected lifetime.

The values for material strength shown in Fig. 4 are the failure values for the material. The values used for the calculation of material properties in use on railway tracks are proven with a safety factor of 5 – 7 and can be obtained directly from SEKISUI. The corresponding specified regulations of the railway operator concerned must of course always be considered.

Recycling/Sustainability

SEKISUI has developed recycling and reusing technology of FFU Synthetic Railway Sleeper. However, since the first sleepers installed in 1980 are still safe in use, the needs are limited.

Any waste produced during the production process such as dust from drilling and chippings from milling can be recycled as well.

For example, FFU in the form of so-called K-FFU, is made from manufacturing waste, has been used in projects in Austria as sole-plates in the area of bridge abutment wall bearings with a constructive height of a few millimetres (Fig. 5).

Fig. 5: 3 mm high FFU layers as bearings at abutment wall

Approval

In 2020, this technology is approved in Europe in Germany, Switzerland, Austria, the Netherlands, the UK, Ireland, Italy, Sweden, Finland and Poland. There is also an EU certificate of May 2016 which confirms inter-operability in the Community.

In Germany, FFU was quality certified by Deutsche Bahn AG Q1 and has the corresponding manufacturerrelated product qualification(HPQ). The EBA approval of 2017 defines the area in which it can be used in ballasted track (track, points) and on bridges with exposed trackway[2].

Technical Values

The FFU Synthetic Railway Sleeper has been investigated and tested by many international technical universities and testing institutes. These include the Technical University of Munich, the Technical University of Milan, the Technical University of Tampere, the Technical University of Brunswick, the University of Southampton and of course the Railway Technical Research Institut in Japan, to name just a few.

If the technical values of FFU Synthetic Railway Sleeper are compared with those of oak wood sleepers, it can be roughly stated that the flexural strength of FFU 74 is about 80 % and the longitudional compression strength is about 50 % higher. Investigations also showed that the elasticity modulus is always in the range of over 7,000 N/mm².

The load deformation curve (Fig. 6) shows that the material properties of the synthetic wood sleeper is linearly elastic over a very large range. that means deformations, which could occur when passing over points in the centre area, which then return to the zero position after the load is removed. This combined with the E-modulus, the material-specific

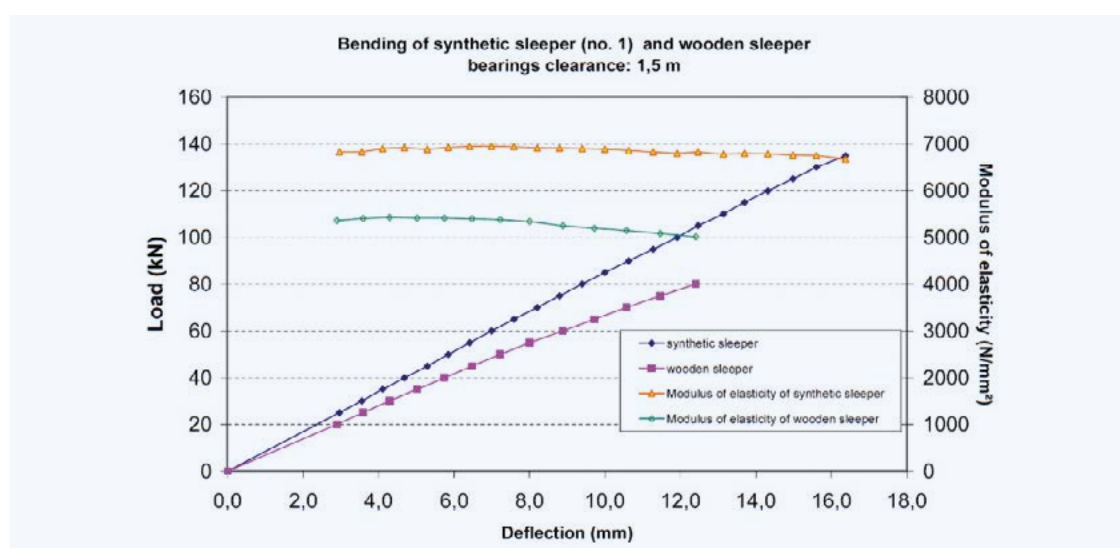

Fig.6: Load deformation curve FFU 74 – Test TU Munich, 2008[2]

warping property under load and the low thermal expansion coefficient of 7.8 x 10-6 /°K leads to an absolute advantage for the railway operators in using them in the area of points.

Deutsche Bahn for example installed two points with FFU sleepers in Würzburg in 2012. In 2011 they also installed two points on concrete sleepers. In 2018, after six and seven years duration respectively, they carried out comparative investigations on these four points. The findings to be reported in a following publication were conclusive in FFUs performed better than concrete.

SEKISUI CHEMICAL CO., LTD., produce FFU in different density. This primarily involved changing the density of the polyurethane used, while the proportion of glass fibre remains almost the same. In this way, this material can be optimised for special demands and uses by railway operators.

Paris Metro RATP, for example, wanted a extraction force of 120 kN per bolt for the bolts used by them. These requirement were met with an FFU 100 sleeper (Fig. 7). These different FFU materials could also be combined. In that way, long timbers were produced from FFU 74 with 6cm of FFU 100 on the upper surface for Network Rail, a rail operator in the UK, for the Newark crossing project. in this way, the compression strength of the railway sleepers could be adjusted to the operator's requirements.

Techn. Values	Unit	FFU 100	FFU 95	FFU 74	FFU 50	RFFU
		High strength	Soft	Standard	Light	Recycling
Density	kg/m³	1,000	950	740	500	1,100
Flexural strength	N/mm²	225	109	142	71	60
E-modulus	N/mm²	16,400	10,490	10,600	7,450	5,000
Compression strength lomgitudinal	N/mm²	108	37	58	29	40
Water absorption	mg/cm²	3	4	3	6	38
Electrical resistance	Ω	$1.0x10^{14}$		$1.6x10^{13}$	$1.0x10^{13}$	$7.6x10^{14}$
Thermal expansion coeff.	[1/°K]			$7.8x10^{-6}$		

All values are average values at which material failure occurs. Values are not guaranteed.

Fig.7: Technical Values of FFU Synthetic Railway Sleeper [4], [5]

Lateral Shift Resistance on Ballast Base- LSR

Proof of the lateral shift resistance (LSR) was strictly specified to gain final EBA approval in Germany. This had to take place on a real track. To do this, together with the TU Munich, SEKISUI installed FFU Synthetic Railway Sleepers in four different construction heights and designs in a new real Deutsche Bahn track in summer 2015. 45 of each type of sleeper were installed and every third one of these was tested [6]. To get a direct comparison with Deutsche Bahn wooden sleepers, 45 wooden sleepers were also installed and tested.

The dimensions of the wooden track sleepers investigated were W/H/L = 16/26/260 cm, the FFU Type 1 synthetic wood sleepers were W/B/L = 12/26/260 cm. The dimensions of the Type 2 FFU synthetic wood sleepers were as for Type 1, although shims each of height 6cm and length 15cm were attached to the underside at each end and the centre of the sleeper. Type 3 had dimensions of W/B/L = 16/26/260 cm. Type 4 was as Type 3, but with shims of height 2cm and 15 cm length on the underside at each end only.

The first measurement was made in an unconsolidated status, that is, after the insertion of the tracks and before any train traffic passed over the tracks. The second measurement took place in a consolidated condition in the summer of 2016, after a traffic load of 33.9 million tonnes had passed over the test section of track.

Results showed that the Type 3 synthetic wood sleeper of construction height 16 cm had an LSR 7.8% lower than that of a wooden sleeper in unconsolidated status. In the consolidated status, the LSR of the synthetic wood sleeper was 14.9 N/mm with a 2mm shift, that for the wooden sleeper was 14.8 N/mm (Fig. 8). Apparently there was an increased working into the ballast bed of the underside of the sleeper with the synthetic sleeper.

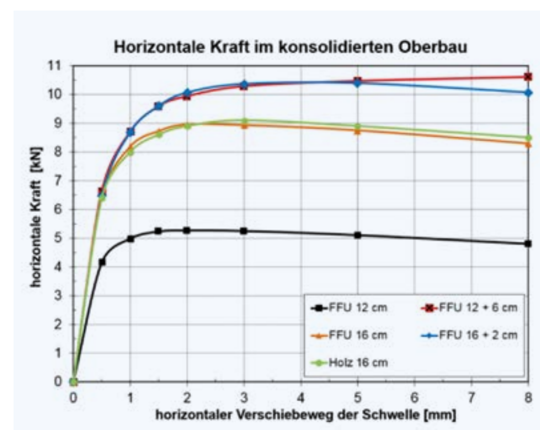

Fig.8 Lateral shift resistance of different FFU synthetic wood sleepers in consolidated upper structure
Type 1 FFU H/W/L = 12/26/260cm, Type 2 FFU H/W/L = 12/26/260 plus 3 shims, each H/W/L = 6/26/15 cm, Type 3 = FFU H/W/L = 16/26/260 cm, Type 4 FFU H/W/L = 16/26/260 plus 3 shims, each H/W/L = 2/26/15 cm, wooden sleeper H/W/L = 16/26/260 cm

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Part 2: Technical Investigations and Work Safety

Chemical Stability – Drinking water quality

Because of the closed cell structure, FFU absorbs almost no water. This technology maintains its full technical function, durability and safety vis-a-vis oils, lubricants and chemical substances used in railway operation, artificial fertilizers, salt, and many other substances.

UV light has almost no effect on the technical quality of FFU Synthetic Railway Sleeper. Uncoated surfaces with prolonged exposure to UV radiation only undergo discoloration of the upper surface, similar to natural wood.

The report OS57110607-1 was completed by “Japan Food Research Laboratories” [1] on 14th November 1994. This gave the chemical breakdown of the water quality test of FFU in relation to the regulation no.69 of the Japanese Health Ministry. The result was that both the immersion test water and the control water comply with the standards for water quality and therefore the quality of the water was not affected.

Fire Properties

The smoke from FFU was classified by DMT GmbH & Co KG in 2009 as non-toxic and safe for use in enclosed installations or for rail infrastructure in Europe that runs underground according to DIN 5510-2:2009-05 [2]. The Institute for Construction Materials, Solid Construction and Fire Safety of the Technical University of Brunswick [3] classified FFU 74 as Bfl-s1, i.e. with low flammability and low smoke production according to DIN 13501-1:2010.

The Institut Techniki Budowlanej in Poland tested FFU 74 in 2017 in respect of safety against fire that could be caused by vandalism [4] at a railway bridge with open steel beams. This was done by starting a fire both on the upper surface of an exact replica of the trackway with steel beams, rails and grating and under the construction, which acted on the sleepers and the construction for 30 minutes. Wind was also simulated in the test. In each test, 20kg of wood was burned. The temperature on the top surface of the first FFU Synthetic Railway Sleeper immediately adjacent to the one directly above the fire reached a maximum of 700° C. Over the course of the test, the fire only spread to the two directly neighbouring FFU Synthetic Railway Sleeper. The three sleepers which has started to burn under this fire load extinguished simultaneously with the reduction of the artificially created fire (Fig. 1 and 2).

Fig.1: Fire test on open steel beam construction (here: Fire on the upper surface of the bridge track)

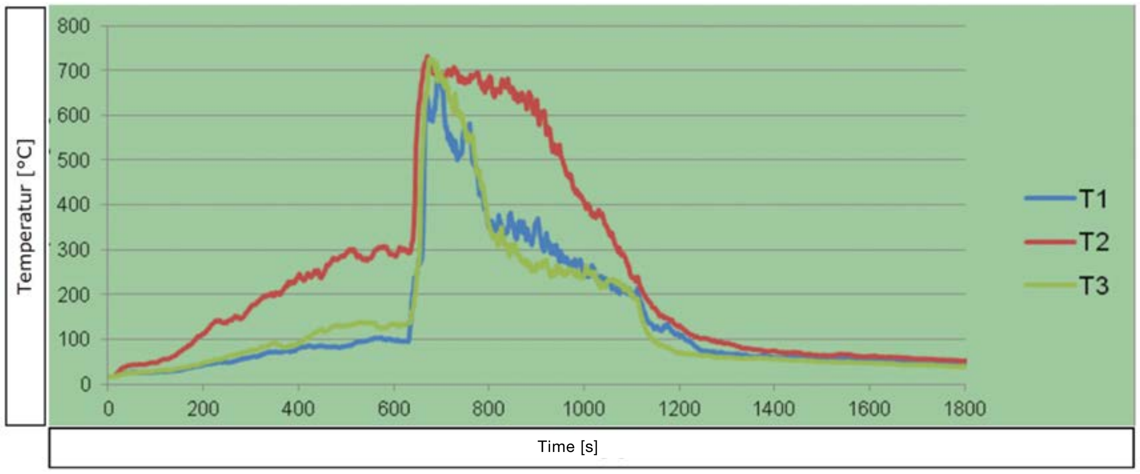

Fig.2: Temperature change on the side surface facing the fire of the sleeper to the left of the primarily affected FFU Synthetic Railway Sleeper (at 3 measurement points).

T1 near the sleeper fixing point on the bridge longitudinal beam left of the centre of the sleeper, T2 in the centre (vertical and horizontal) of the sleeper, T3 near the sleeper fixing point on the bridge longitudinal beam right of the centre of the sleeper.

As a result of the investigation, the laboratory issued a qualification certificate [5], certifying FFU74 as non-fire spreading, self-extinguishing and without any negative effects on the fire safety of this bridge construction as a building material.

Investigation at Minus 65 Degrees Celsius

The University of Tampere in Finland tested FFU synthetic wood sleepers at very low temperatures that can arise in Finland[6]. The initial target temperature was at least minus 40 degrees Celsius, but the cooling apparatus led to even lower temperatures. All load tests were load-controlled and carried out according to European Standard EN 13230-2,which describes the load test for concrete sleepers. In this, a static load is applied to the centre of a sleeper. The distance between the support points was 1,600 mm, the supports were 100 mm wide. Two vertical deformation gauges were installed directly above the support points and two more deformation gauges directly below the point of application of the load.

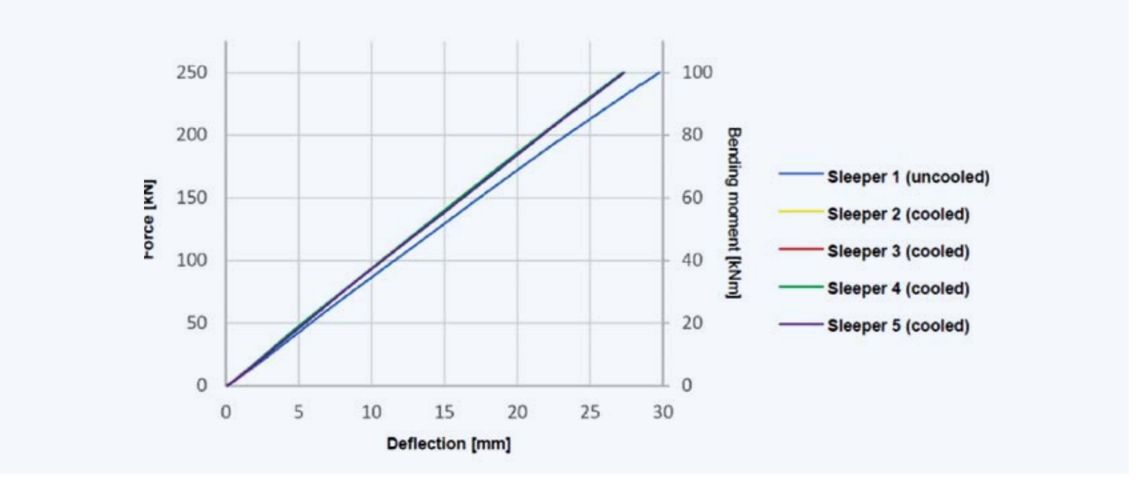

Fig.3: Load-deformation curves for FFU Synthetic Railway Sleepers in the low temperature test

The temperature of the sleepers was measured at three points during the application of the load. One point was embedded about 80mm deep within the sleeper, the second point about 30 mm deep within the sleeper and the third temperature sensor measured the temperature of the sleeper surface.

A total of five FFU sleepers with dimensions H/W/L = 160 x 260 x 2,600 mm were tested. One of the sleepers was stored at room temperature (20° C), four were cooled with dry ice in an insulated box for at least 24 hours. This cooled the sleepers to temperatures of -65 to -70° C. The sleepers were not cooled during the tests, so that the surface of the sleepers warmed by the end of the test by nearly 20°, by about 10° at 30 mm depth and at 80 mm depth by less than 1°.

All the load deformation curves are shown in figure 3; the maximum load was 250 kN. The results of the bending tests demonstrate very high flexural strength. The rigidity of the material increased slightly at low temperatures. The differences between the individual tests were not clearly shown in figure 3.

All the FFU Synthetic Railway Sleeper were visually inspected after the tests. No cracks were identified in the bending force area on the surface of the sleepers. An average E-modulus of 8,933 Mpa was determined for the 5 tested sleepers.

A comparison of the synthetic wood sleepers with wooden sleepers shows that the average breaking load of a new wooden sleeper in similar static tests (temperature +20° C) is 80 to 100 kN.

The elasticity modulus of new wooden sleepers of dimensions B/W/L = 240/160/2,700 mm is about 7,300 MPa. The tests showed both that the FFU sleepers can carry high loads and that they are also elastic. Very low temperatures cause the sleepers to become a little more rigid but there was no effect on the quality of the sleepers such that the FFU sleepers can safely carry the loads of the Finnish railways rolling stock.

Maintenance Investigation- Würzburg Points

In September 2012, Deutsche Bahn installed two points with FFU Synthetic Railway Sleeper at Würzburg station. A year previously, two new points with concrete sleepers had been installed on the parallel track. The loads and speeds of the four points are the same, that is an average of 70,000 tonnes per day making 25.5 million tonnes a year at 60 km/h. One of the two points with synthetic wood sleepers was an EW 54-300-1:9 I K (WITEC) and the other an EW 54-500-1:12 I K (WITEC).

In autumn 2018, Deutsche Bahn carried out investigations of the four points in respect of the expense of maintenance and positional stability. Measurements were made at the

- rail surface
- rail cross section
- the frog tip

and visual and ultra-sonic inspections were carried out.

The track and geometry of the track location were tested using the Krabbe system, and the sleeper cavity position at the frog was investigated. Points test sheets, discussion and inspection records, the final report of the operation test and the accompanying booklets were evaluated [7] in respect of the regular inspection every six months of track, opposite height position, groove width and tongue test in an unpublished bachelor's thesis in the University of Bochum.

The aim of this bachelor's thesis was to show the differences in maintenance of different effects on concrete and synthetic wood sleepers in points.

The investigations of points with FFU Synthetic Railway Sleeper showed:

- The track fastening in the points is free from defects.
- The rail fastenings are free from rust, the load is transferred, and the tension is correct.
- The sleepers are free from damage and in a defect-free status.
- The switches are free from visual defects on rails and the set of switches.
- The interim rails and sets of the switches are free of any indications for head checks or other rail defects.
- No Sonic Sound inspections eddy current check was necessary as no visual defects were identified.
- The sleeper recess position measurements with SMM 200 in the course of train travel on the main and branch track showed the different deformation properties of concrete sleepers and FFU Synthetic Railway Sleepers.
- Indentation measurements showed the expected “softer“ deformation properties of FFU thresholds (Fig. 4).

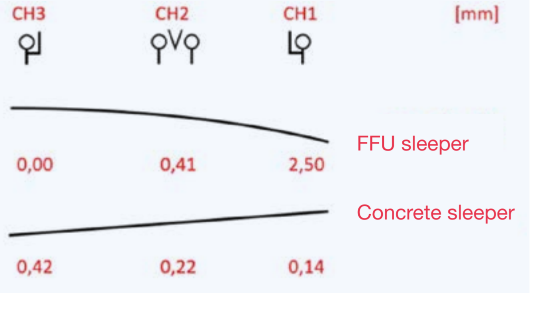

Fig.4: Flexing of FFU synthetic wood points sleepers (branch track right) and concrete (branch track left), cross section through the points at the frog region.

LCC Bridges

The Life Cycle Cost Analysis “LCC Bridges” [8] is concerned with bridge timbers fastened directly to exposed steel bridge beams in the Deutsche Bahn network.

The results of the economic efficiency calculation can be summarised as follows:

- If the (remaining) life expectancy of the bridge beams exceeds that of the wooden sleeper by even one year, then it is economically expedient to use FFU Synthetic Railway Sleeper.
- For long (remaining) life times of the bridge, there is a high potential saving from using FFU Synthetic Railway Sleeper. The domestic interest rate with a bridge lifetime of 120 years is a very high 25%.

The base scenario shows a cost saving for FFU Synthetic Railway Sleepers if the remaining lifetime of the bridge exceeds the lifetime of the wooden sleepers; the annuity of the wooden sleepers is about double that of the FFU sleepers (Fig. 5). Put another way, even if wooden sleepers only have to be replaced once, FFU Synthetic Railway Sleepers are the more economical option. The lifetime of wooden bridge timbers will be reduced with the banning of creosotes and other impregnating preservative coating materials normally used up to now. An investigation of this with a reduced lifetime of the wooden sleepers of 8 years shows that the annuity for wooden sleepers is about three times as high as that for FFU Synthetic Railway Sleepers (Fig. 6). The amortisation duration for FFU Synthetic Railway Sleepers falls to 9 years.

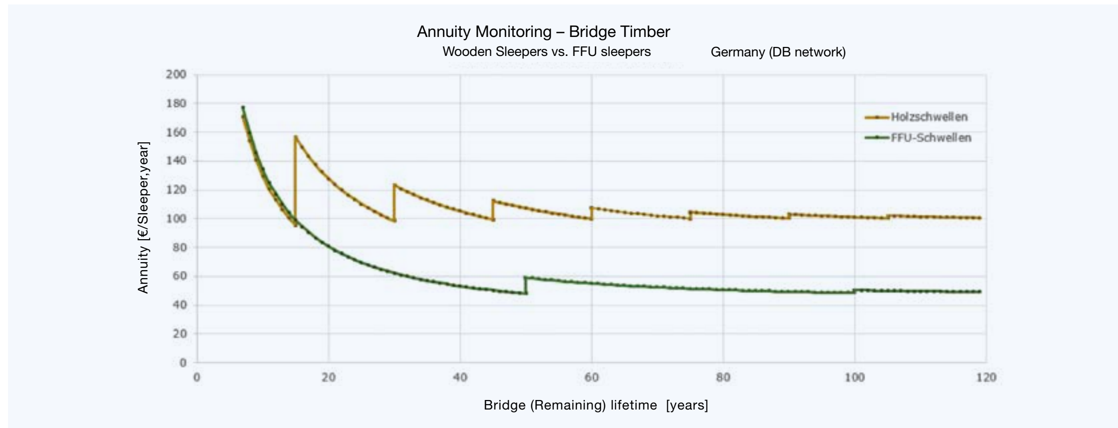

Fig.5: Annuities of bridge timbers against bridge lifetime

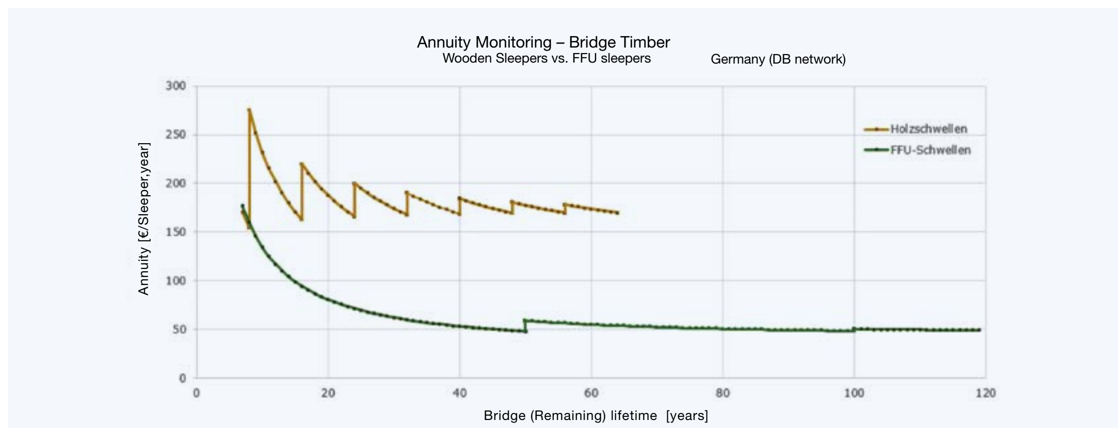

Fig.6: Annuities of bridge timbers against bridge lifetime – reduced wooden sleeper lifetime 8 years

Works in the Project

FFU Synthetic Railway Sleeper can be worked with the same tools and the same methods as natural wood railway sleepers. Milling, sawing with a hand-held circular saw or power saw, chiselling and all conceivable kinds of woodworking can be carried out just as they are with natural wood. The drill diameter for the sleeper bolts is slightly larger than for wooden sleepers. A diameter about 4 to 5 mm smaller than the nominal diameter of the sleeper bolts to be used is recommended (Fig. 7).

Fixing elements used for wood can also be used for FFU Synthetic Railway Sleeper. Since these sleepers consist of glass fibres, there are some additions to the generally applicable working regulations for working on the sleepers, such as for example, that any drilling waste from working on site should be extracted with an industrial vacuum while the drilling is made and then disposed of as industrial waste.

Fig.7: Drilling the holes for sleeper bolts

Work safety – TNO – Investigation

The TNO (Dutch Organisation for Applied Scientific Research) carried out investigations in 2017 in respect of the effects of fine dust produced in working on the sleepers with reference to the legal specifications [9].

SEKISUI produces FFU Synthetic Railway Sleeper from fibre-reinforced polyurethane. During mechanical working of FFU Synthetic Railway Sleeper on site, harmful substances might be released which constitute a possible exposure risk to employees. The substances possible released include respirable und inhalable dust, glass fibres, diisocyanates and products of the thermal decomposition of diisocyanates.

Realistic „worst case“ simulation measurements were made under standardised conditions. The investigations were made in two different ways:

1. With emission-reducing according to the working guidelines for FFU Synthetic Railway Sleeper
2. Worst case simulation without emission-reducing measures.

The following equipment and emission-reducing measures were used:

- Drill – with and without extraction
- Hand chainsaw – without extraction
- Electric planer - with and without extraction
- Belt grinder / manual grinding- without extraction

As the FFU technology represents an alternative to the conventional oak railway sleepers, the measured dust concentrations were also compared with the dust emission data in the corresponding processes for hardwood, to show the results by comparison.

The extensive study made by the TNO showed that in general the concentrations of respirable dust are lower with FFU than with hardwood. Working with FFU Synthetic Railway Sleeper meets the corresponding regulations of Germany and Sweden, which have the most demanding working regulations in Europe.

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Part 3: Applications and Summary

Areas of Use

Points
The very long forecasted life of 50 years and the excellent linear-elastic material properties, and the high chemical resistance of FFU Synthetic Railway Sleeper are decisive in the preferential use for points, which are so important to railway operators. Operators, and the businessmen who are regularly faced with high costs and maintenance expenses in individual points, appreciate the sustainable advantages of FFU Synthetic Railway Sleeper.

Investigations by Deutsche Bahn showed that no maintenance work is needed after 7 years of operation and 70,000 tonnes load each day on two points with FFU. All parts of the points were still in absolutely the correct position and no grinding of the rails was needed. The original frogs were also still in a defect-free status.

FFU Synthetic Railway Sleeper is produced to customised length with dimensional consistency and used in points equipment in ballast beds, on steel bridges and on solid trackway.

Changing an existing point with wooden sleepers to one with FFU Synthetic Railway Sleeper does not need the conversion of the existing substructure that would be needed for the higher concrete sleepers. U sing 14cm height FFU Synthetic Railway Sleeper can improve the height of the ballast bed with the same gradient.

Four decades of experience have confirmed the shape stability and elastic properties of FFU Synthetic Railway Sleeper in points areas. This technology gives railway operators safety, availability, and minimises maintenance work especially in the high-load frog area.

In the construction of points, the shape stability of FFU Synthetic Railway Sleeper and the consequent positional stability is attractive for the work of fitting the points. Fast and safe, partly fully automated fitting of points on the engineering side means a very short loss of capacity for the works. Points with FFU Synthetic Railway Sleeper have a density comparable with that of wood (740 kg/m^3) and advantages in the transport and installation logistics (Fig. 1).

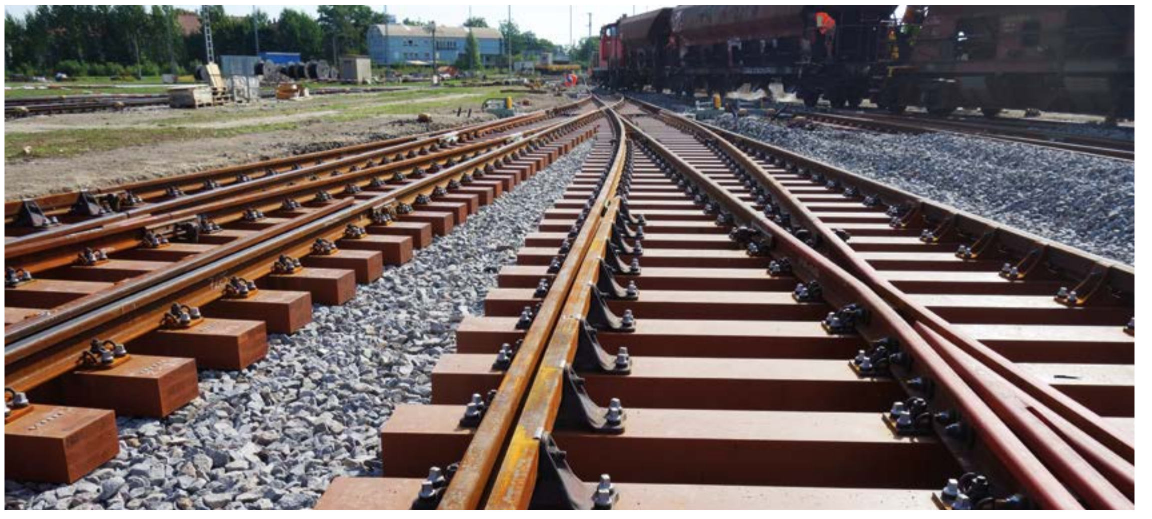

Fig. 1: Deutsche Bahn – Points in the Nuremberg marshalling yard

Bridges
In technical and economic terms, FFU Synthetic Railway Sleeper can be used just the same way as conventional natural wood timbers on railway bridges. Using them creates a high additional benefit to engineering in bridge construction and long-term sustainable benefits to the environment (Fig. 2).

One example, which prompted one of the first European operators to use FFU synthetic wood on its bridges was the extension of the maintenance intervals:

- Corrosion protection after 30 years
- Rail renewal after 30 years
- Steel construction after 50 years
- Renewal of FFU Synthetic Railway Sleeper after 50 years

With the realisation of the target specifications given above, the railway operator only has to implement another long track closure leading to significant disruption to railway operation after

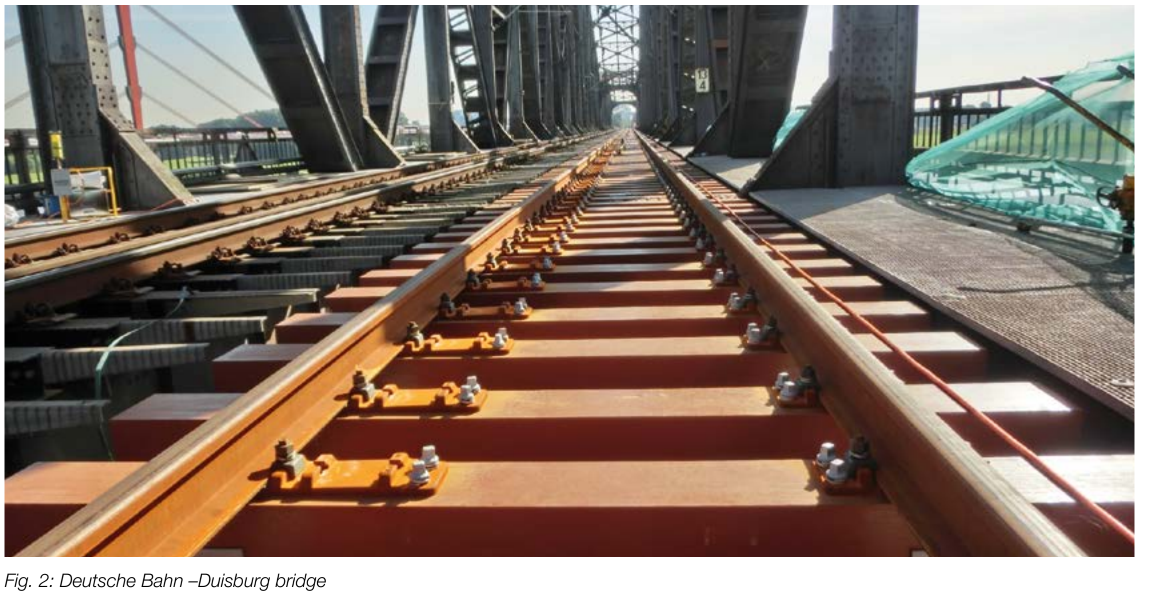

Fig. 2: Deutsche Bahn –Duisburg bridge

50 years. Maximum availability of the tracks is a primary aim for most railway operations.

Special shapes

The Federal Railways Office in Germany and the Federal Transport Office in Switzerland granted approval in 2017 and 2019 respectively for using the flat sleepers in the German and Swiss railway.

In the process of the close cooperation with employees of Deutsche Bahn, it was seen that there are always pressure points requiring very cost-intensive maintenance. This is especially so where the construction height of the ballast under the conventional sleepers is not enough or where the engineering structure above or below the track restrict the railway's headroom.

Since 2008, the Vienna local transport has been continuously installing FFU Synthetic Railway Sleeper with a construction height of 10 cm, for example in the track of the route 31 tram on the Floridsdorfer bridge with direct fixing. A total of 1,600m of track using this technology was established.

As a large part of the Vienna underground network is equipped with polyurethane sleepers from the 1970s and 1980s which have now reached their life expectance, there is currently a long-term programme of exchanging these sleepers for FFU Synthetic Railway Sleeper, on solid trackway or on heavy and light mass-spring systems in tunnel locations.

In 2012, the Bochum-Gelsenkirchen Straßenbahn AG (Bogestra), a tram company in Germany built a set of points with 10 cm high FFU Synthetic Railway Sleepers on a ballast bed.

Sleepers with a constructive height of 12 cm are being used on a Deutsche Bahn track in the Hanover area that carries 100,000 tonnes a day.

The Rhaetian Railway in Switzerland has been fitting 12 cm high sleepers to bridge structures since 2014.

Longitudinal beams in railway bridges are particularly used in the English-speaking area (Fig. 3). The dimensions of these longitudinal beams manufactured from FFU and installed to date were up to 16,000 mm length, 700 mm width and 510 mm height. Bi-block sleepers with this technology have also been created and installed. The first solid track tunnel project was equipped with this as long ago as 1980.

Level Crossings

In the past, level crossings on branch lines were usually constructed from wood. The fast weathering and very high demands of agricultural and forestry vehicles and equipment, whilst maintaining the required safety for crossing pedestrians mean that wood constructions are having to be replaced within a very short time, e.g. on average every 6 years in UK

Fig. 3: Network Rail, Great Britain, Newark Railway Junction

Fig. 4: ÖBB, Protectors in the mountains, synthetic wood level crossings

In contrast to wood, FFU Synthetic Railway Sleeper is based on a nearly non-porus material, it does not absorb water, does not need chemicals that are harmful to the environment (protection of nature and water) and it is highly weather-resistant. These aspects increase the safety of the crossing and offer the certainty of a longer functionality.

Many level crossings have already been built FFU Synthetic Railway Sleeper in Japan and Austria (Fig. 4). In view of these short lifetimes, preparations are taking place for the first projects in the UK where not just the level crossing, but the sleepers around the crossing will be built with FFU synthetic wood too.

The old crossing can be removed and being replaced with FFU Synthetic Railway Sleeper in a short period of time. It can be immediately re-opened to both crossing and rail traffic.

Special solutions

In the area of mainline railways (22.5 t axle load), in Europe sleepers with a construction height of 10cm, width 26cm and length 2.6m. Especially in area of bridges with ballast tracks and on regular tracks at points where the ballast thickness under the sleepers can be maximised by this. Points sleepers of length up to 9.6m have also already been installed in Japan and other sleepers around insulated rail joints with a width of up to 60 cm in one piece are in use.

For trams and underground railways, the minimum constructed height is 10 cm with a minimum length of 2.01 m. Areas where these are used are light and heavy mass-spring systems, direct fixings on bridges and on points on ballast tracks.

Longitudinal sleepers in a single piece of dimensions of up to 70cm width, 16m length and 35 cm height have been installed on the British and Irish networks on points and bridges.[1]

Dimensions of a construction height of 3 mm and L x W = 20 x 20 cm for linings and other special safety measures and all required shapes of wedge have been produced and installed to achieve the same lifetime and the same material properties as railway sleepers (Fig. 5).

The Timeline of Use in Europe

Wiener Linien [Vienna local transport] were the first to use FFU Synthetic Railway Sleeper in Europe in 2004 in the Zollamtsbrücke project. Austrian Railways [Österreichische Bundesbahn] followed in 2005. Private companies in Germany and the Hamburg city railway have been fitting points with FFU since 2008. Deutsche Bahn then installed this technology in three bridge projects in 2011. Since then, Deutsche Bahn has been using FFU Synthetic Railway Sleeper in the areas of bridges, points, marshalling yards and as flat sleepers and longitudinal beams in points sets with wooden sleepers.

Many local transport operators in Germany have been using synthetic wood sleepers in the areas of points, tracks, and bridges since 2015.

The Netherlands first installed synthetic wood in 2012 in three bridges.

The first projects in Switzerland using FFU as points sleepers, flat sleepers on bridges with ballast tracks and as standard bridge sleepers were completed in 2014.

Network Rail in the UK is using FFU in the form of longitudinal beams of dimensions W/H/L = 45/35/750 cm in two bridge projects.

Belgium followed in 2015 with a bascule bridge, the French rail operator Tisseo in Toulouse with two points in solid track and Network Rail with longitudinal beams in the bend in Rochester. This means that the upper surface of the longitudinal beams has different slopes both in the lateral and longitudinal directions. Each corner of the beam has a different construction height.

Fig.5: London Underground Chiswick Park, FFU wedge and layer pads

Fig. 6: Paris Metro RATP - FFU in points in the new tracks M4 and M11

Keolis in Lille (France) has been using FFU Synthetic Railway Sleeper at two sets of points on a solid trackway since 2016. The Paris Metro RATP uses FFU in points on the new stretches of track on the M11 and M4 in a solid trackway (Fig. 6), BaneNor in Norway uses synthetic wood on a bridge and in points in the Oslo Metro, and London Underground on several bridges.

Irish Railways and the Stockholm local transport have been installing FFU in some very large bridge projects since 2017. In Stockholm, the bridge in the Gamma Stan [Old Town] area is being completely rebuilt with 5 tracks, located above the Stockholm drinking water reservoir. More than 2,000 pieces of „FFU Synthetic Railway Sleepers are being used here. 2 sets of points in ballast and many points on the bridge are also being equipped with FFU.

Ferrovia Nord in Italy has equipped a bridge and 2 sets of points with this technology since 2018. Spain has fitted points for the Catalan railway company FGC with FFU.

In 2020, the Finnish railway set up the first test tracks for FFU in section tracks with increased incidence of vibration and fitted a bridge with FFU. The Italian railway RFI plans to use it for several bridges in 2021.

Advantages of Using FFU

In respect of the economic efficiency of using this technology, Deutsche Bahn showed with the investigation of points on FFU with 6 years of operation that the maintenance costs in this time were virtually zero.

The Life Cycle Cost analysis by the TU Graz shows a possible internal rate of return of up to 25% when using FFU on the Deutsche Bahn's steel bridges.

This technology has been in use in Japan since 1980, and in 1985 RTRI forecast a life expectancy of 50 years or 1.7 billion tonnes of load. This forecast was reconfirmed in 2010 for sleepers that had been in use for 30 years and were investigated by RTRI. This results in a maximised availability of the track for the operator.

In terms of safety, experience and references, this technology can refer to more than 1,550km of installed equivalent track (as it is mainly on bridges and at points) and 40 years of use. The gauge remains safe due to the strength and the low thermal expansion coefficients. The linear elastic properties of FFU are guaranteed to the minus 65 degrees Celsius it has been subjected to in tests.

This high-quality material is produced under the strictest internal and external quality monitoring and has been awarded the Q1-certification from Deutsche Bahn.

SEKISUI Chemical Co. Ltd., the developer and manufacturer of FFU, has been listed as one of the 100 most sustainable companies in the world every year since 2016 by the Toronto-based media and investment consultancy company Corporate Knights. In 2020, Sekisui Chemical Co. Ltd. was being ranked as the 12th most sustainable company on the planet.

In times of ever-increasing environmental awareness, FFU shows that it is free from insecticides and soluble chemicals. The investigations by the TNO already described in the second part of this article showed that working with FFU on site is safer than working with natural wood. Weathering and the environment have no effect on the durability and functionality of this material and the sleepers and the use of FFU in the track system brings about no chemical reactions with the environment. At the end of the forecast lifetime of 50 years, FFU Synthetic Railway Sleeper can be recycled and resuable.

FFU Synthetic Railway Sleeper can be worked with on the track in the same way as natural wood using high quality tools. On request, pre-prepared drillings precise to the millimetre, processing of any kind, doubling, numbering and much more can be carried out in the factory.

With a density of 740 kg/m^3, individual sleepers can be moved without any special lifting gear and no increase of the tare load on a bridge.

In the high-load frog areas, the linear-elastic material property shows no permanent deformation of sleepers even after millions of tonnes of load.

In ballast trackways, there is the same inter-meshing with the ballast as there is with natural wood. This was shown by the Munich TU during a test of lateral shift resistance carried out on an actual track.

The rail-based local transport operators use the very high electrical insulation of this high-quality material for precise localisation of their vehicles using track circuits.

Summary

Together with Japanese railways, Sekisui developed Fibre Reinforced Foamed Urethane, FFU Synthetic Railway Sleeper in 1978. The first two projects were fitted with this technology in 1980. The Japanese RTRI – Railway Technical Research Institute – subsequently removed these first projects in the years 1985, 1990, 1996 and 2010 and tested them for technical quality with positive results.

FFU Synthetic Railway Sleeper has been installed on more than 1,550 km of track in the areas of points, bridges, and special solutions as well as level crossings since 1980.

The first project in Europe was realised in 2004. The final EBA-approval for 22.5 t axle load and speeds up to 230 km/h was granted in 2017. Sekisui then received the Q1-certification of the Deutsche Bahn.

By 2020, most European countries have used FFU in railway projects. This technology is also being used in Australia, USA, Asia, India, and South America.

SEKISUI has been continuously among the 100 most sustainable companies in the world since 2016 and was awarded the Global 100 Award for this. The life expectancy of FFU as sleepers of 50 years or 1.7 billion load tonnes and the recyclability at the end of the useful life reflect this award.

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Photos: Sekisui Chemical GmbH und koocoo technology & consulting GmbH

2016 | Chiswick Park | London Underground

Shiga Ritto Plant | Japan

FFU PRODUCTION

Shiga-Ritto Plant, which locates next to Kyoto, Japan, is the manufacturing plant of FFU since its development in the 1970s'. It also has its own research and development office for this high-end technology. About 100,000 FFU Synthetic Railway Sleepers are produced and quality controlled annually in this plant. Then, the sleepers are transported to the countries around the world.

Main Office

Research and Development Office


Bridge sleepers with space for rivets on the steel girders of the bridge

FFU Synthetic Railway Sleepers are produced under safe, quality controlled, and clean circumstances. SEKISUI assembles bespoke sleepers with high dimension accuracy. Drilling, gluing, milling, cutting, and many other fabrication can be prepared. Before painting, sanding is conducted which improves the look of the sleepers. Waste produced during the production process can be recycled.

Drill hole for sleeper fastening screw at the bridge construction

Bridge sleepers including lateral inclination.

Some of the clients have situations where they look for special solutions.
SEKISUI always tries their best to fulfill such unique requests


Special sleeper solution for the lateral crossing of the track by cables

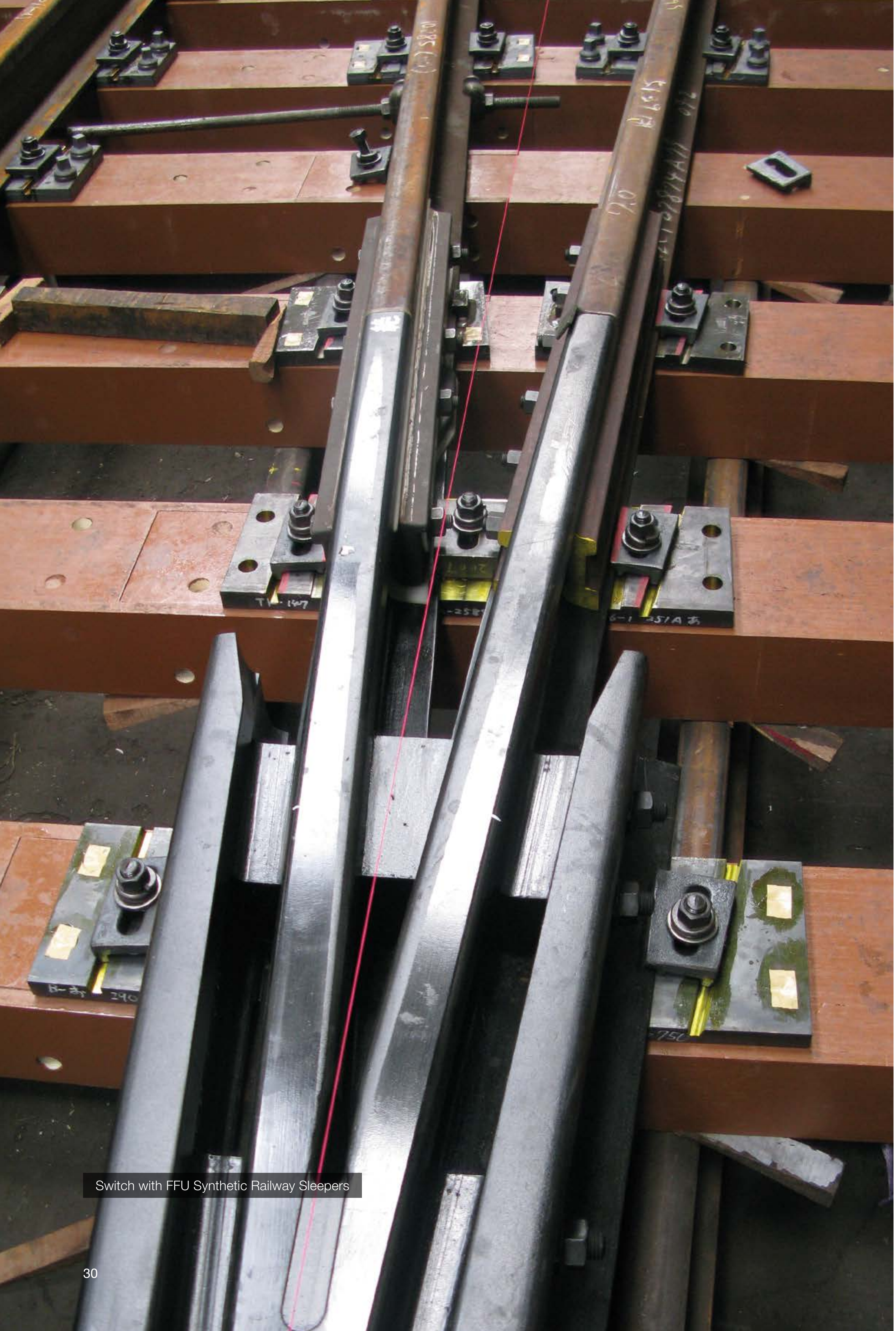

Bridge sleeper with packing and special milling for the bearing area


Bridge sleeper with packing and special milling for the bearing area

2020 | Tokyo Station | JR East

JAPAN

In the 1970s‘, Japanese Railways observed that the lifetime of wooden sleepers they were using was short and they sought new materials. SEKISUI CHEMICAL CO., LTD., who developed a synthetic material behaving like wood but not influenced by weather, was invited and started working with Japanese Railways to develop a new type of railway sleepers. In 1980, the first FFU Synthetic Railway Sleepers were installed at a bridge and in a tunnel for field tests.



Switch with FFU Synthetic Railway Sleepers

In 1985, RTRI took several sleepers from the field test and examined them. The result was impressive. Since 1987, FFU Synthetic Railway Sleepers have started to be installed in Shinkansen lines, where trains run 320km/h at maximum.


FFU Synthetic Railway Sleepers at an Open Steel Bridge on Shinkansen Track

Shinkansen, the Japanese high-speed train, is in use since 1964. A big part of its track runs on viaduct, and FFU Synthetic Railway Sleepers are mainly used at switches on concrete slab track. Some of the sleepers are placed on elastic materials. The space between the sleepers and the elastic materials is filled with ballast packed in nets, so that the air born noise can be reduced.


Shin-Tosu Station | Kyusyu Shinkansen | JR Kyusyu

2021 | Tokyo Station | JE East and JR Kokkaido

Since 1988, FFU Synthetic Railway Sleepers have been used in Shinkansen lines (high-speed lines) in Japan.

The Shinkansen train shown in this picture is E5 Hayabusa (Peregrine falcon) series at Tokyo station. The Hayabusa runs between Tokyo Station and Hakodate-Hokuto Station, 823.8 km (511.9 miles), in 3 hours and 58 minutes with maximum speed 320km/h (approx. 200 mph) by East Japan Railway Company (JR East) and Hokkaido Railway Company (JR Hokkaido).

Togawa Bridge | Tobu Kinugawa Line | Tobu Railway

A lot of regional railway operators in Japan have started to replace wooden sleepers on their bridges to FFU Synthetic Railway Sleepers.

2011 | Kyushu Shinkansen Kagoshima Central Station | MINE-SEISAKU-SHO CO., LTD.

FFU Synthetic Railway Sleeper has been installed at various types of track including switches, crossings, turnouts, bridges, expansion joints, ballasted track, slab track, direct fixed track, longitudinal bridge baulks, and furthers.

2010 | Kasagi Bridge | Nankai Electric Railway

2005 | Assembly of a Turnout with FFU Sleepers

SEKISUI has developed joint sleepers for switches. Those joint sleepers are consist of FFU Synthetic Railway Sleepers, FFU plates, FFU plugs and glue. Consisting of same FFU materials, its lifetime remains identical to FFU itself.

2007 | FFU Joint Sleepers

Higashi-Hakuraku Station at Toyoko Line | Tokyu Railways

Benefits of FFU Synthetic Railway Sleeper for bridge transom application are its light weight and longevity. This with nearly the same weight as timber sleepers but much longer product life, FFU sleeper is one of the best options for the replacement work of transoms at open deck steel bridges. The walking deck can also be made by FFU.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2020 | Near Ochanomizu Station Marunouchi Line | Tokyo Metro

FFU can be fabricated and assembled flexibly for various railway applications. This gives SEKISUI the opportunity to offer solutions to unique requests. As shown in the picture, the approach way to the track for road-rail vehicles is an example of FFU railway application.

2011 | Kichijoji Station | Keio Line

FFU is also used as a walking deck application. It is suitable for such application because of its high durability, corrosion resistance, and electrical insulation property. Also, FFU has an excellent workability like wood. Thus, it can be cut easily on site for the length adjustments.

2011 | Kichijoji Station | Keio Line

2017 | Duisburg bridge | German Railways

GER MANY

In order to get approval for the use in German railway tracks, the first negotiation started between Deutsche Bahn, EBA (the German Federal Railway Authority), Technical University of Munich, and SEKISUI in 2007.
The first FFU Synthetic Railway Sleeper installations in railway track of Deutsche Bahn took place at a bridge in 2011, and at a switch in 2012. SEKISUI obtained the general approval for bridges, turnouts and tracks from EBA, and HPQ and Q1 Certificate from Deutsche Bahn in 2017.

2015 | Kumhausen | German Railways

FFU Synthetic Railway Sleepers are sometimes prepared in special shapes according to the technical and economical requests by clients. For example, in order to reduce the initial cost for materials, SEKISUI sometimes offers FFU Synthetic Railway Sleepers with lower heights compared to the existing railway sleepers. The target rail level was achieved by placing FFU height adjustment materials on the bottom of sleeper where in contact with the bridge girders.

2017 | Franfurt/Main | German Railways

FFU Synthetic Railway Sleeper can be used at open deck bridges and viaducts in terms of safety of discharging water from elevated structure. FFU has been tested and clarified by the Japan Food Research Laboratory that it does not have influence on the quality of drinking water.

2013 | Menden | German Railways

2013 | Menden | German Railways

2016 | Essen | DVG

Switches, turnouts, crossings, and points are the locations where high investements are needed to keep safety and availability of the track. The linear elastic material behavior of FFU Synthetic Railway Sleeper and its lower elasticity compared with other stiffer railway sleeper technologies help railway operators to keep their maintenance costs low while keeping the track availability high.

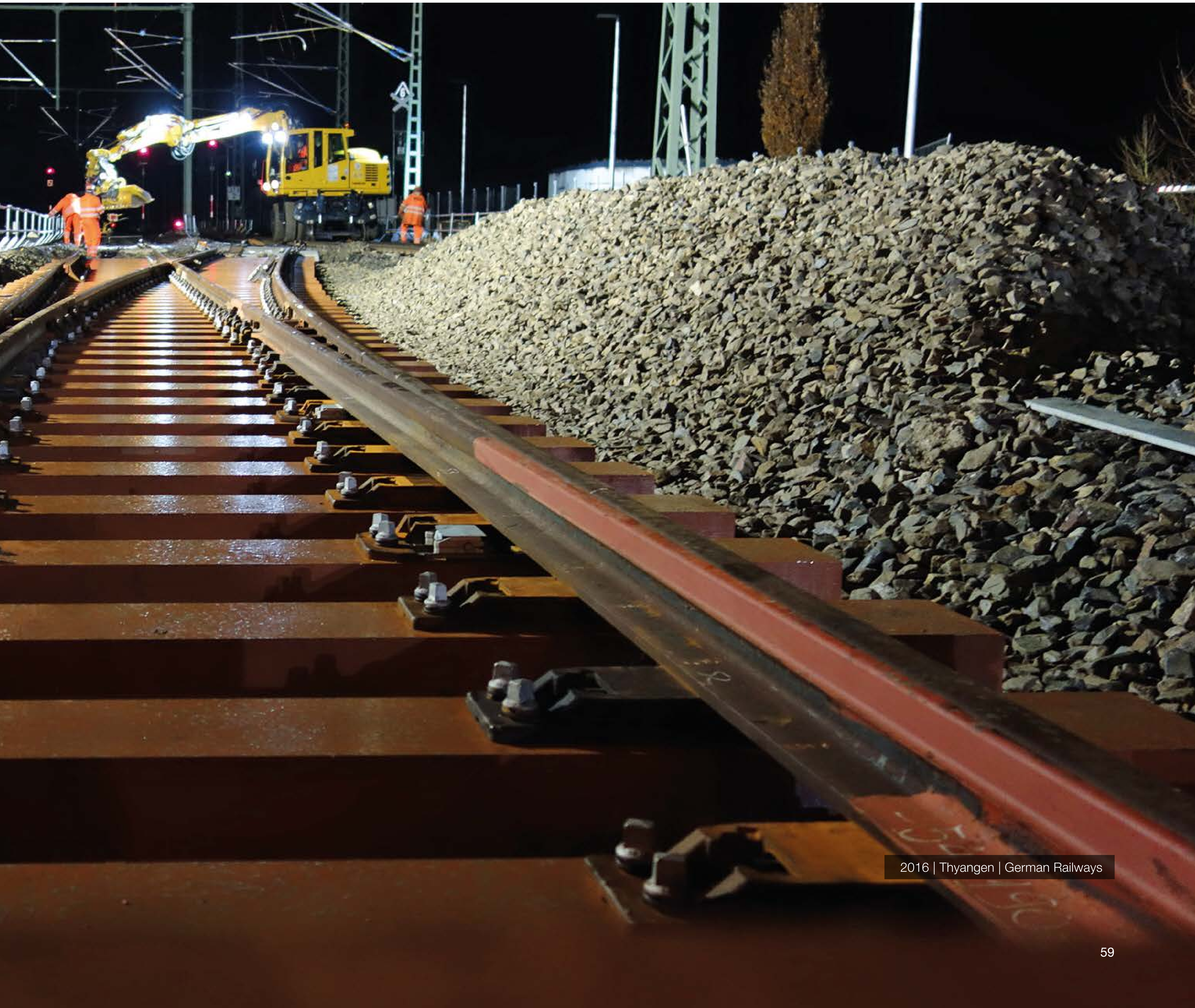
2008 | Leverkusen | Currenta

Final preparation such as drilling, cutting, and chiseling can be done on site with the same equipments for natural wood.

2012 | Bleicherode | German Railways

2011 | Vilsbiburg | German Railways

After having good experiences, Deutsche Bahn has started installing FFU Synthetic Railway Sleepers more and more for rehabilitation.



2016 | Thyangen | German Railways

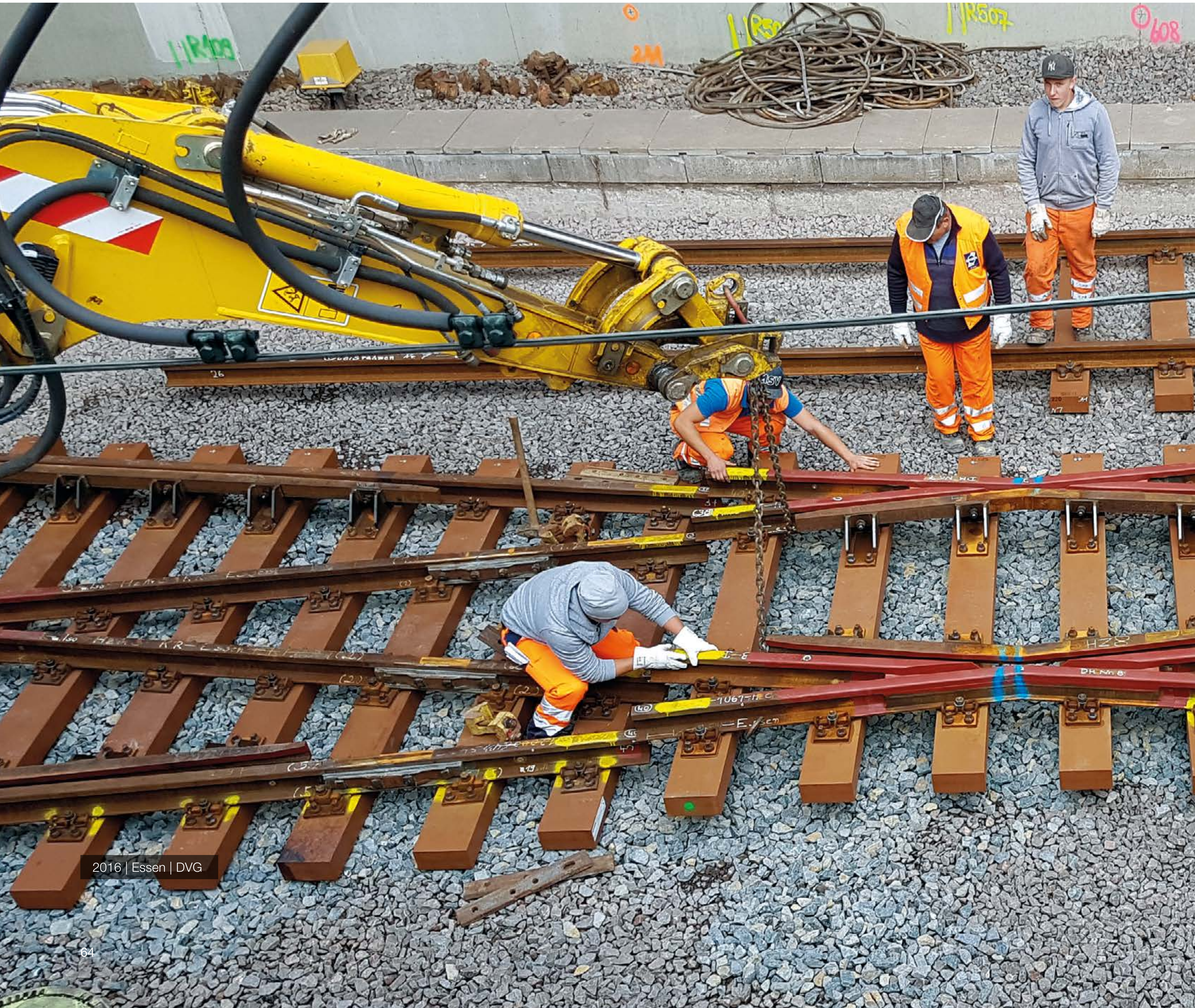
2018 | Marshalling yard | German Railways

Some of the railway operators prefer to replace wooden sleepers to FFU Synthetic Railway Sleepers at their marshaling yards due to the high possibility of derailment during train composition. FFU Synthetic Railway Sleeper has a similar behavior like wooden sleepers if a wagon derails. Also, it has a longer life time and linear elastic load/deflection line.

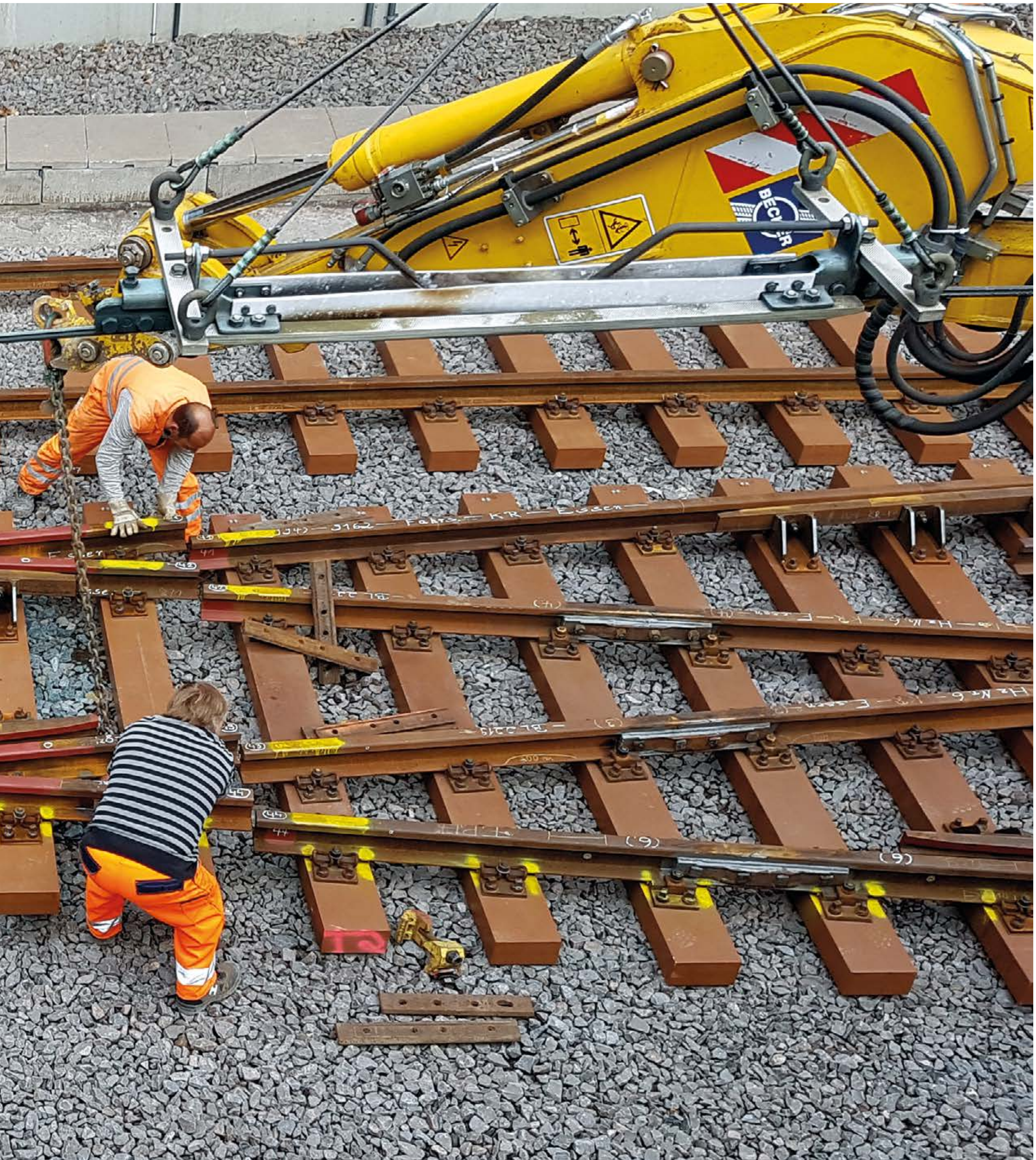
2012 | Würzburg | German Railways

In 2012, the first two switches with FFU Synthetic Railway Sleepers were installed by Deutsche Bahn at Wurzburg main station. Everyday, about 70,000 tons with an average speed of 60km/h are running over these switches.

2012 | Würzburg | German Railways



2016 | Essen | DVG



Some of the city railway operators in Germany use FFU Synthetic Railway Sleepers with 10cm height at their switches.

2019 | Stralsund | German Railways

FFU Synthetic Railway Sleepers have been installed at both small and large bridges. Clients tend to like its durability and workability on site that enable them to have high track availability.

2019 | Meppen | German Railways

In 2021 German Railways installed over 2,200 FFU Synthetic Railway Sleepers at Herrenkrug bridge. The bridge was build in 1979 with a length of 680 m.

2021 | Herrenkrug bridge over Elbe | German Railways

2014 and 2017 | Ashford | Network Rail

GREAT BRITAIN

Longitudinal baulks, special diamond crossing, joint sleepers for switches, and special big dimension frame solutions for brides have been used in Great Britain. SEKISUI is always delighted to work closely with the clients to find the best solution for their track.

2016 | Chiswick Park | London Underground

Special projects sometimes need careful preparations. London Underground and SEKISUI made it happen at Chiswick Park project in 2016.

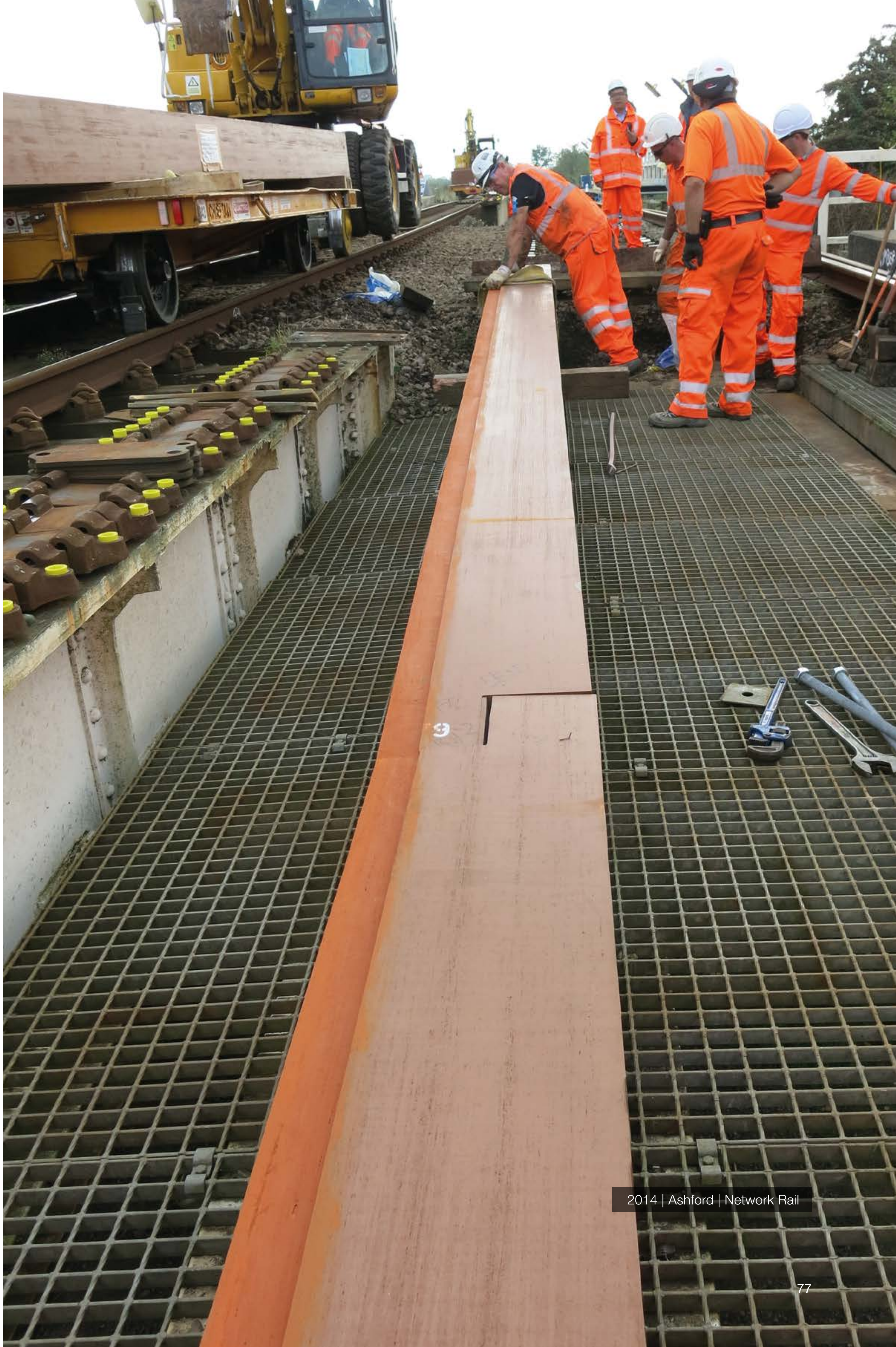
2016 | Chiswick Park | London Underground

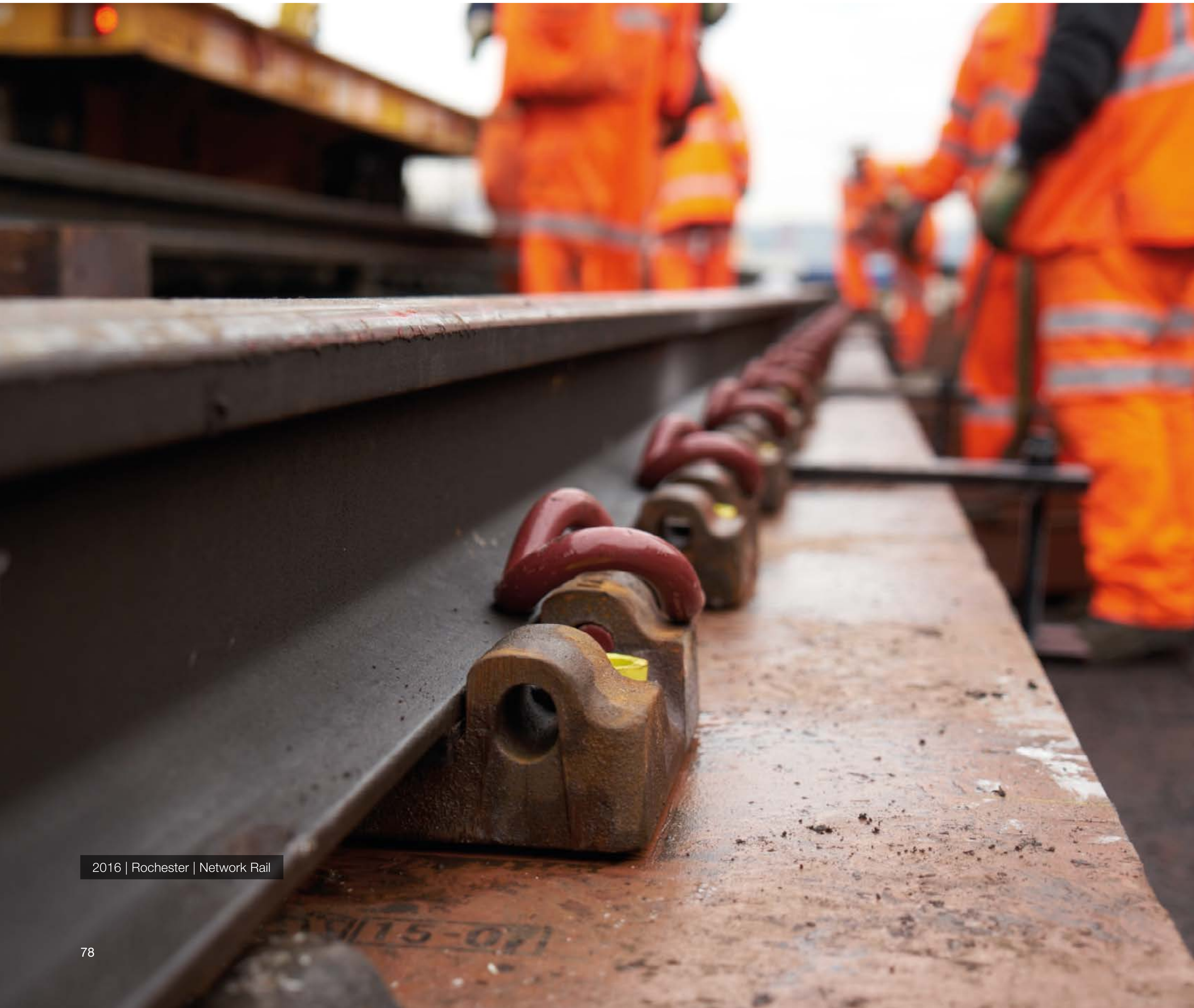
FFU Bridge Frame Sleeper construction. Assembled by the team of London Underground at their workshop. 3mm height FFU plates were used on site for positioning.

2016 | Chiswick Park | London Underground


2016 | Rochester | Network Rail

FFU Longitudinal Bulks with up to w/h/l=45/42/750cm. The bulks had different height at each corner because of the inclination of the curve for both longitudinal and lateral directions.



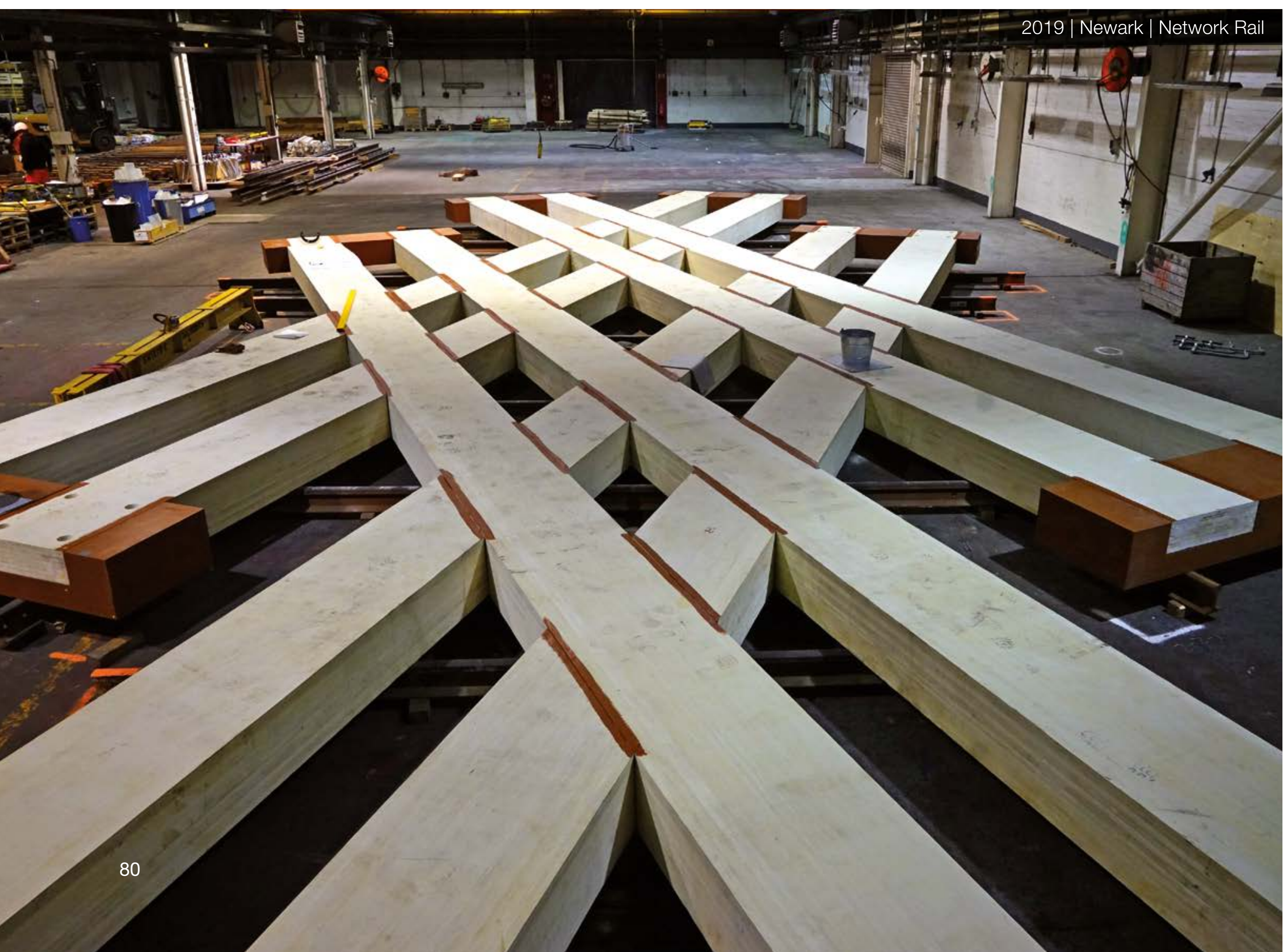


2016 | Rochester | Network Rail

As FFU 74 has a density of 740kg/m³, it can be lifted by two people without any equipments.

2019 | Newark | Network Rail

Carrying 160km/h inter-city trains running and with heavy traffic on, the trackwork on the timber crossing had to be replaced every eight to ten years at this Newark crossing. Purchasing suitable material for a further renewal proved problematic, so Network Rail has decided to adopt alternative technology. Two densities of FFU 74 and 100 (740/1,000kg/m³) were combined to give an increased compressive strength at the surface.



2019 | Newark | Network Rail

2019 | Newark | Network Rail

Huge unique FFU perfect!

16m long, 710mm wide, and 350mm high bearers were installed in 2019. Due to the limitation of production and transportation, 8m long FFU were produced in Japan, and shipped to the UK for final assembly. After eight weeks, the bearers were finished, numbered, painted, and assembled. The construction on site went very smooth and took 4 days as scheduled.

2019 | Newark | Network Rail

General process of technology development starts with simple ideas and solutions goes over to complex one and ends finally at simple and perfect one.
FFU Synthetic Railway Sleeper – simple the best solution!

2019 | Newark | Network Rail

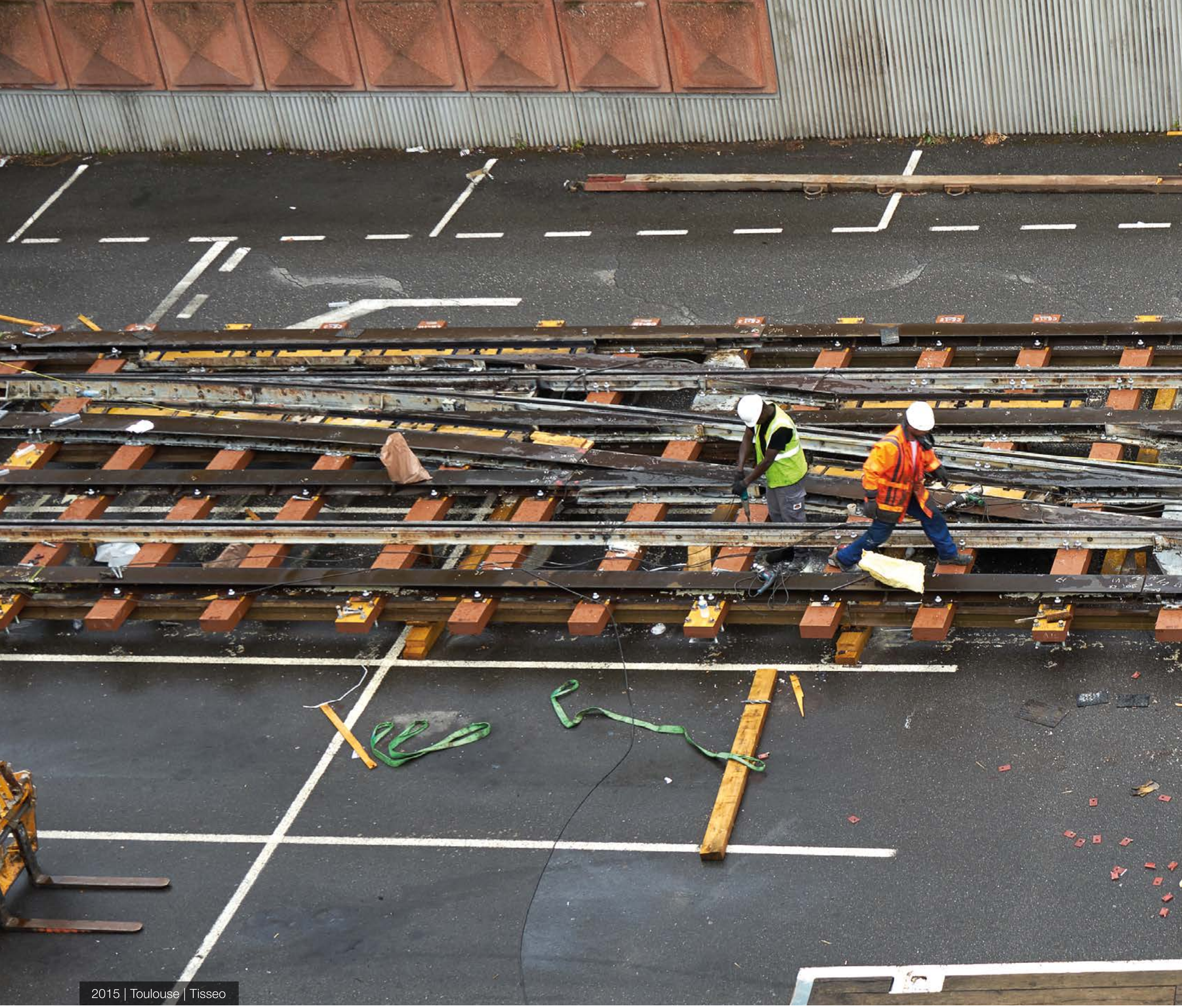
2016 | Lille | Keolis

FRANCE

In 2015, the first project with FFU Synthetic Railway Sleepers in France took place in Toulouse. Tisseo installed two switches in existing slab track with FFU Synthetic Railway Sleepers. Keolis in Lille followed in 2016, and also RATP (Paris Metro) in 2018. RATP installed FFU100 at their new lines M14 and M11.

RATP required pulling-out strength of 120kN for fastening screws. They have decided to install FFU100 which has a density of 1,000kg/m3 and higher technical figures than FFU74 which is widely used as railway sleepers.

2018 | Paris | RATP

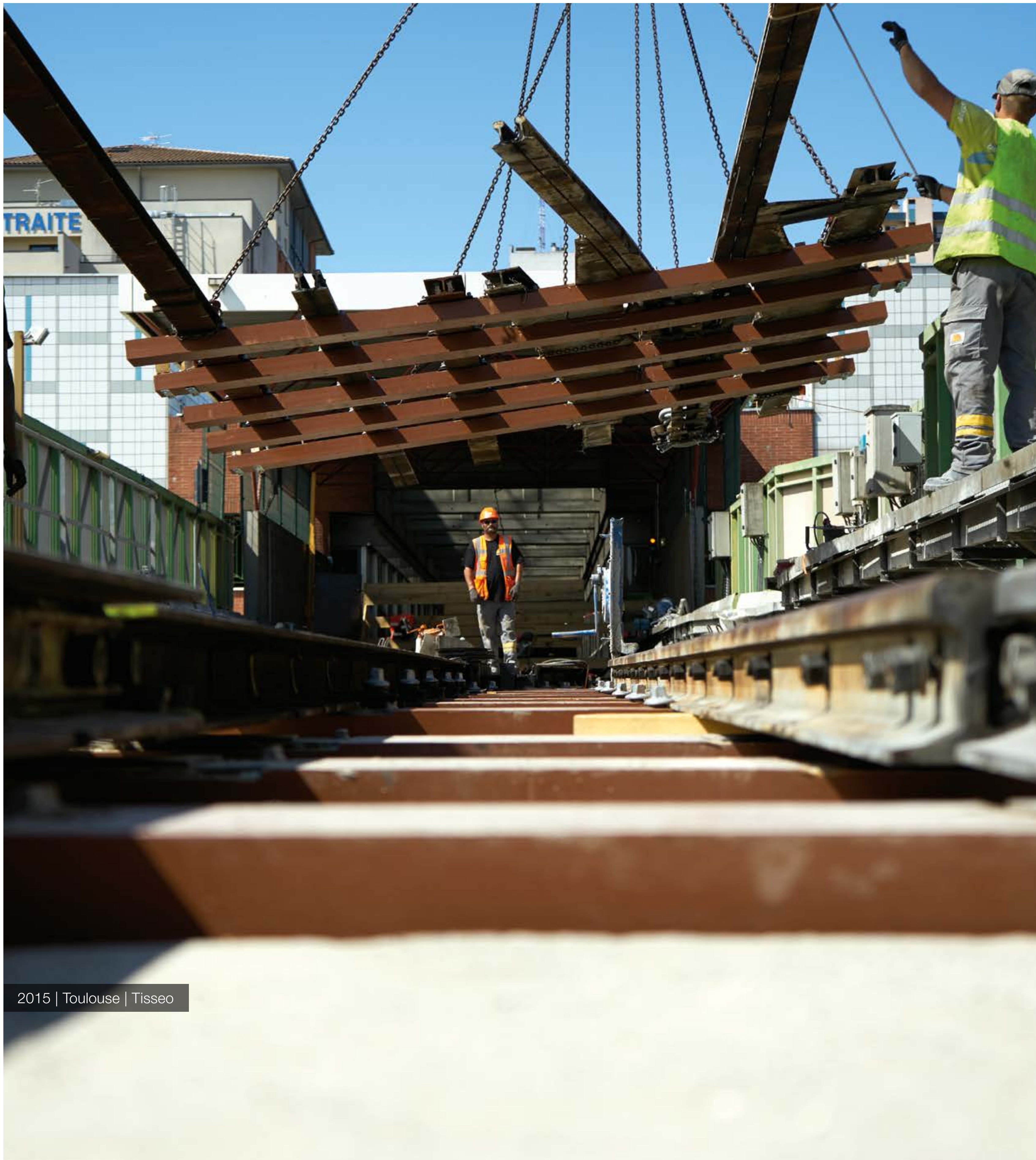


2015 | Toulouse | Tisseo

FFU Synthetic Railway Sleepers were delivered to Vossloh Cogifer in 2015. The switch manufacture assembled the sleepers according to the requirements, and the final construction was conducted on site. FFU Synthetic Railway Sleepers were finally embedded in elastic material in the existing slab track.


V2 EXT

Replacing the superstructures from wood to FFU Synthetic Railway Sleeper. With similar workability, elasticity, and higher technical figures and longer service life.



2015 | Toulouse | Tisseo

2015 | Toulouse | Tisseo

2015 | Davos | RhB

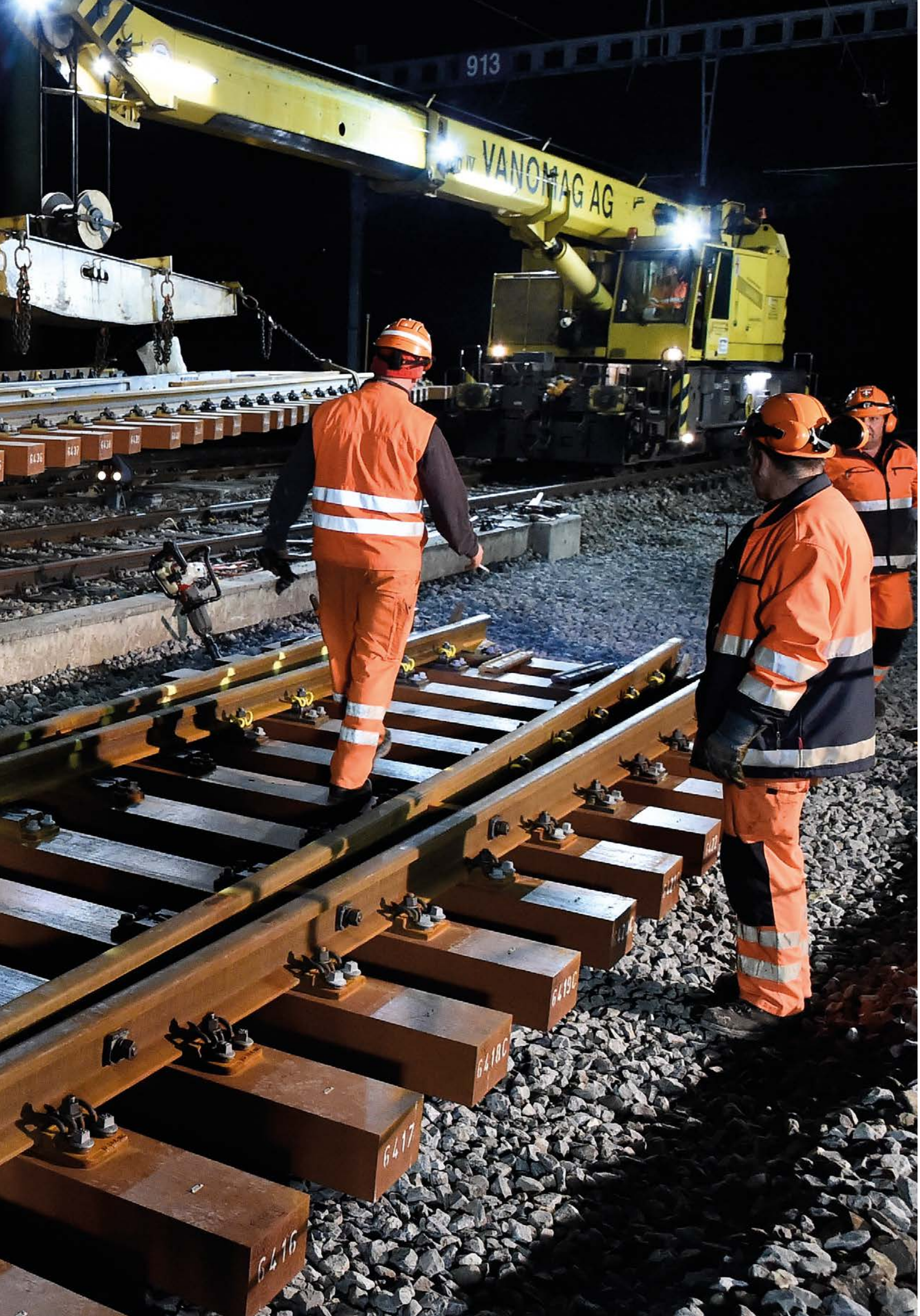
SWITZER LAND

On average, 2,400km per person travel by train every year within Switzerland, which is one of the highest figurers in the world. In 2014, FFU Synthetic Railway Sleeper obtained BAV trial approval starting from 12cm height. Since then, the sleepers have been installed at numbers of bridge and switch areas in Switzerland.

2014 | Frutigen | BLS

Switches in Switzerland are produced with the lowest tolerances in the railway industry in Europe. Dimension accuracy of FFU Synthetic Railway Sleeper meets their requirement.

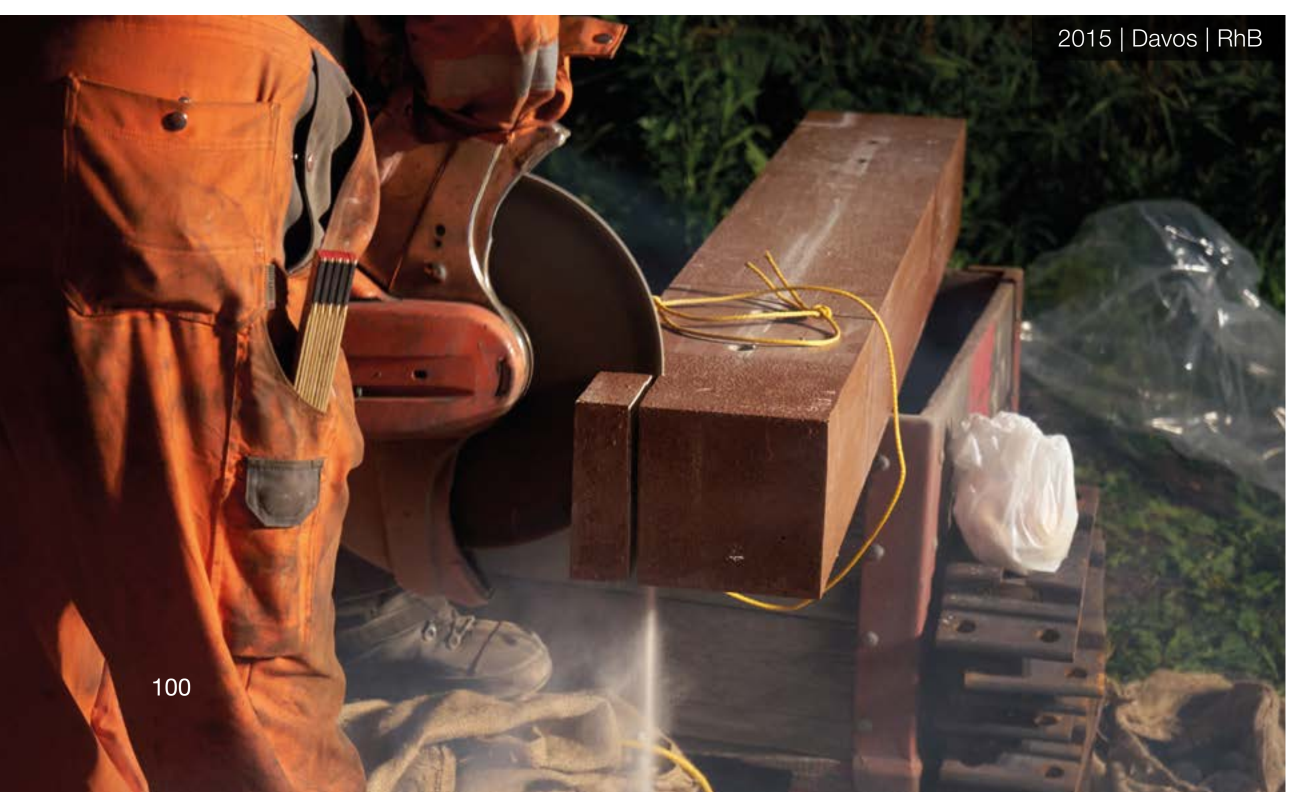
2014 | Frutigen | BLS



Stable product performance need a low thermal expansion coefficient too.
Concrete 0.014 mm/m/°C
Construction steel 0.0129 mm/m/°C
FFU 0.0075 mm/m/°C
Wood 0.0033 mm/m/°C

A study of fine dust from different materials have been performed by TNO. The study showed that in general, the consideration of inhalable dust during processing activities is lower with FFU compared to the activities with hardwood.

2014 | Grossdobel bridge | RhB

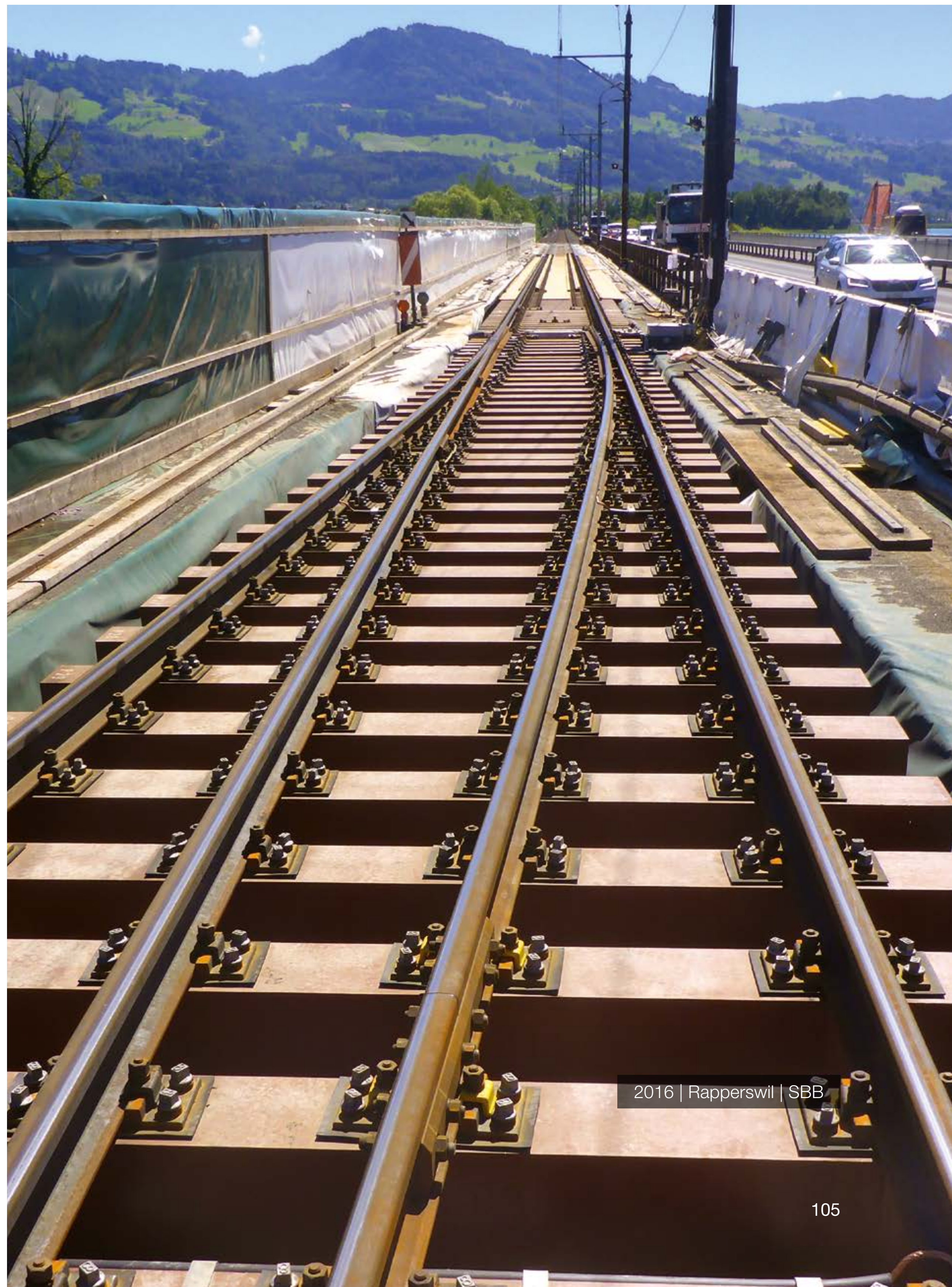

2015 | Davos | RhB

2016 | Goppenstein | BLS

Goppenstein Station is the first station in Europe where all switches and crossings are running on FFU Synthetic Railway Sleepers.

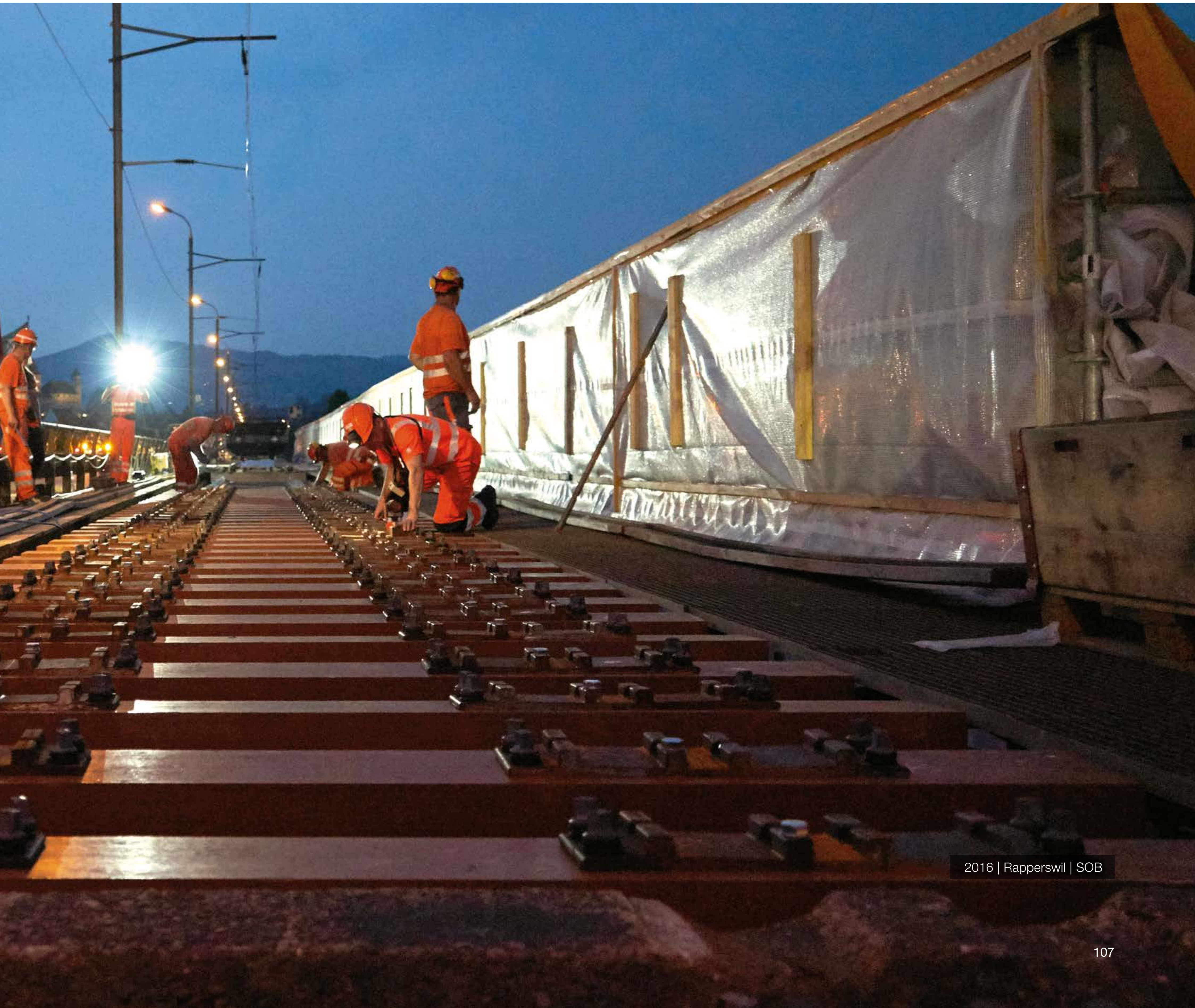
2015 | Rapperswil | SOB

Protecting the nature and the environment, this for generations is a duty we have to stay for. Including investments in high performing and sustainable products like Swiss Railway operators.

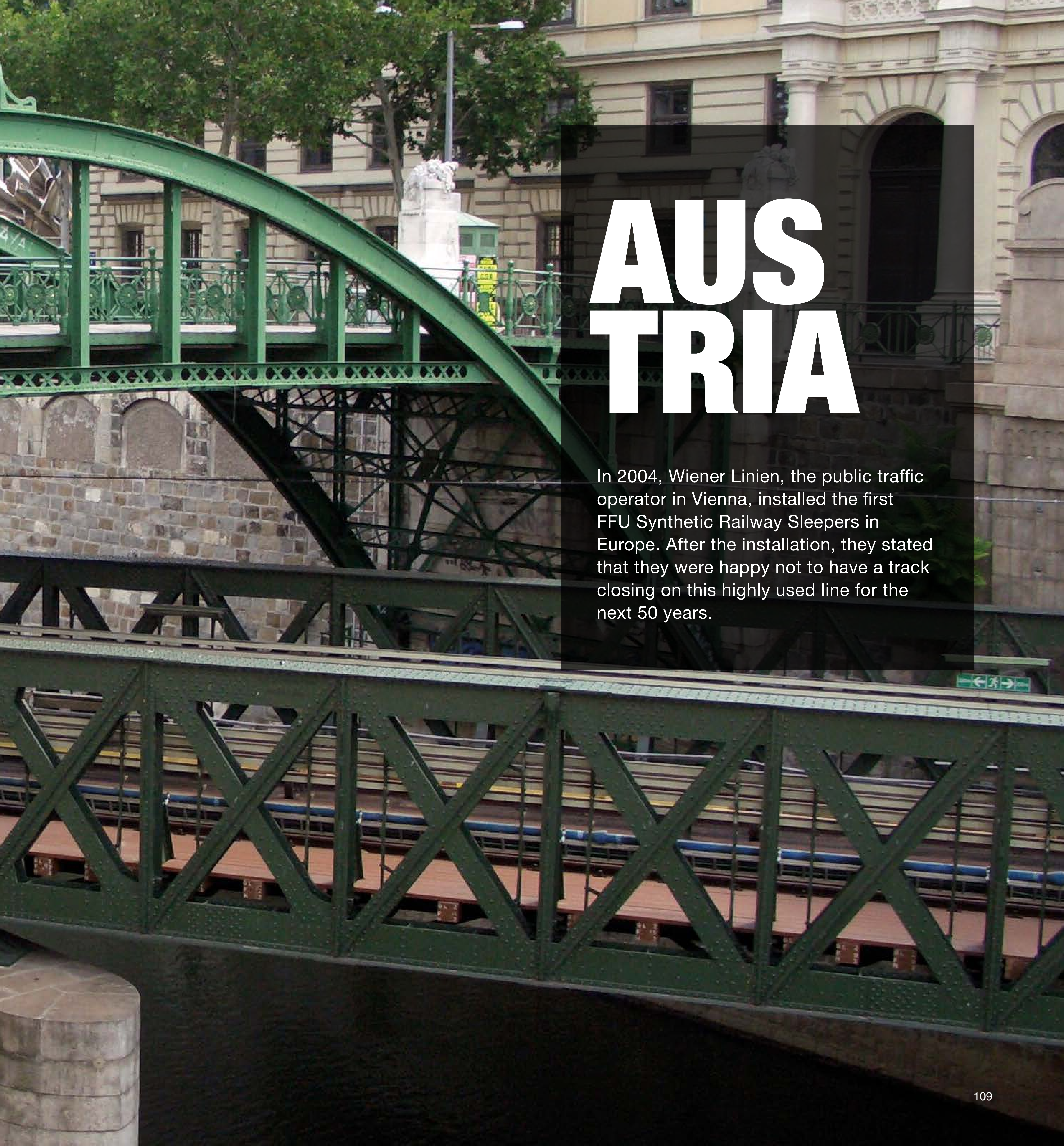


2016 | Rapperswil | SBB

Safety and again safety the railways responsibility and highest duty starts already during the design, followed by the installation and finally the operation and availability of track.


2016 | Rapperswil | SOB


2004 | Zollamtsbrücke | Wiener Linien

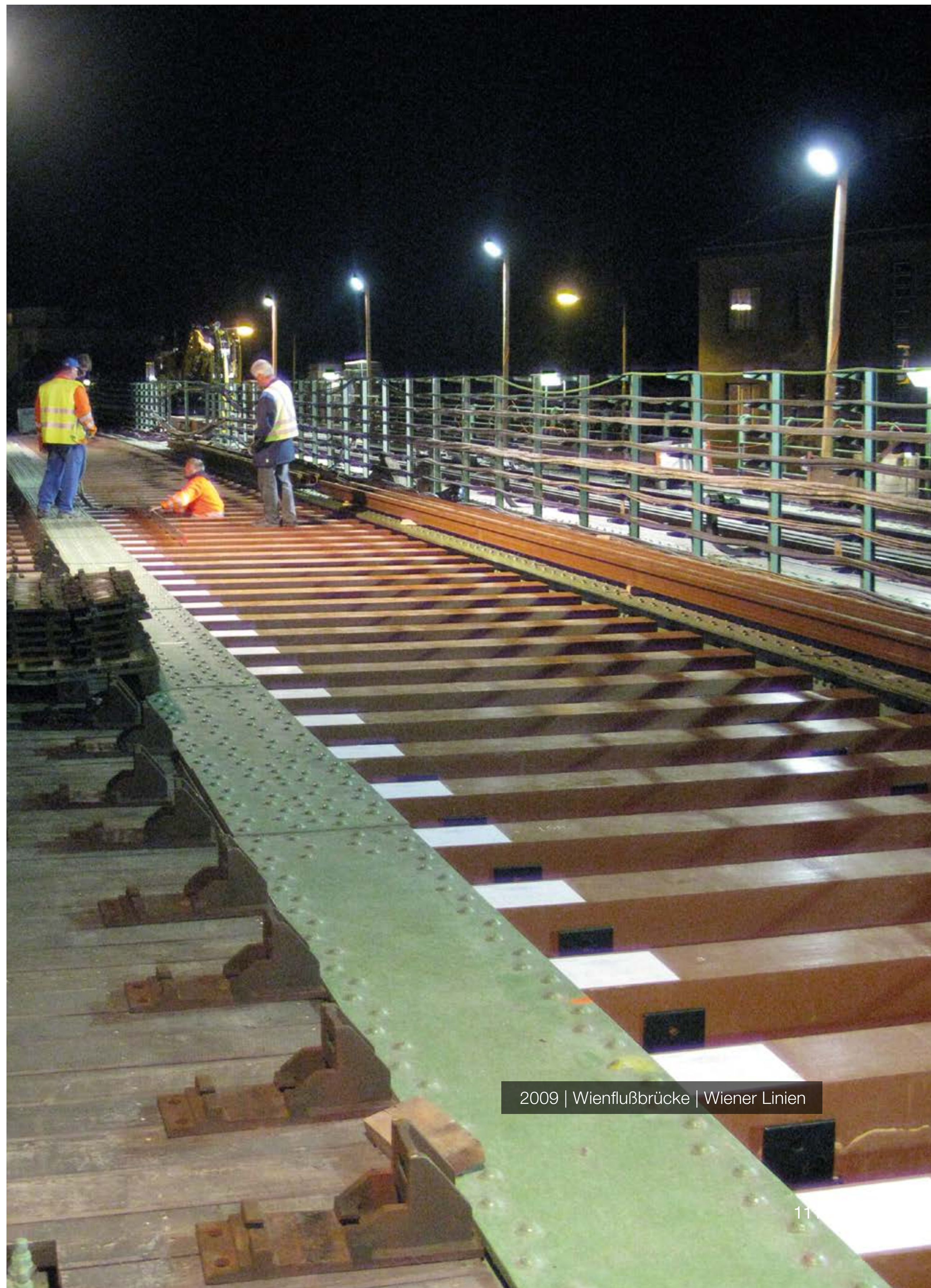


AUS TRIA

In 2004, Wiener Linien, the public traffic operator in Vienna, installed the first FFU Synthetic Railway Sleepers in Europe. After the installation, they stated that they were happy not to have a track closing on this highly used line for the next 50 years.

2012 | Breitenfurter Straße | Wiener Linien

In 2005, the second project with FFU Synthetic Railway Sleeper took place on a bridge of OBB (Austrian Federal Railways.



2009 | Wienflußbrücke | Wiener Linien

2018 | Marshalling Yard Kledering | ÖBB

In 2018, OBB installed 60cm wide FFU Synthetic Railway Sleepers at their marshaling yard in Kledering. This was to reduce the compression into the ballast during the run over. FFU can be produced up to 60cm width in one piece.


Sand
TGr 143
Werkst
St Pölten

2009 | Karwendelbrücke | ÖBB

If an open steel bridge is running over a river or natural water, FFU is an environmentally friendly solution. It has been tested for drinking water projects.

2009 | Ostbahnbrücke | ÖBB

As a study in Germany has confirmed, the linear elastic material behavior up to -65°C, thermal expansion coefficient of around 60% from steel/concrete, and the e-modulus of more than 7,000MPa of FFU Synthetic Railway Sleepers lead to minimize maintenance costs for switches.

2018 | Marshalling Yard Kledering | ÖBB

UP to 2020, FFU Synthetic Railway Sleeper has been installed at nearly all open steel structure bridges of Wiener Linien.

2004 | Zollamtsbrücke | Wiener Linien

2004 | Zollamtsbrücke | Wiener Linien

2020 | Galway station bridge | Irish Rail

IRE LAND

Iarnród Éireann, the Irish national railway operator, had their first FFU project in Limerick in 2017. Following this experience, further installations have taken place at bridges and also switches.

At Ube Bridge in Limerick, FFU Longitudinal Bulks are running under the rail and resting on cross steel bridge girders.

2017 | Limerick bridge | Irish Rail

2017 | Limerick bridge | Irish Rail

2018 | bridge over river Ticino | Ferrivia Nord

ITALY

In 2018, the first installation in Italy was conducted by Ferrovia Nord. They have decided to use FFU Synthetic Railway Sleeper because it is fully approved by EBA in Germany, has a life expectancy of 50 years or 1.7 billion load tons, and also has a positive result on LCC analysis performed in Austria.

2018 | bridge over river Ticino | Ferrivia Nord

Two types of FFU Synthetic Railway Sleepers were installed on this bridge –transoms and about longitudinal baulks. FFU Longitudinal Baulks were placed on the steel deck of the bridge and the rail was directly fixed to the baulks. On the next days, the installation of the transomstook place. FNM managed to finish all the work over a weekend track closing as scheduled.

2018 | bridge over river Ticino | Ferrivia Nord

2020 | Barcelona | FGC

SPAIN

In 2020, the first switch with FFU Synthetic Railway Sleepers in Spain was installed by FGC, Ferrocarrils de la Generalitat de Catalunya. Total of 90 pcs of FFU Synthetic Railway Sleepers were installed. For a fast and smooth construction, drill holes for screws were pre-drilled at SEKISUI production plant in Japan.

2017 | Gamla stan | SL

SWEDEN

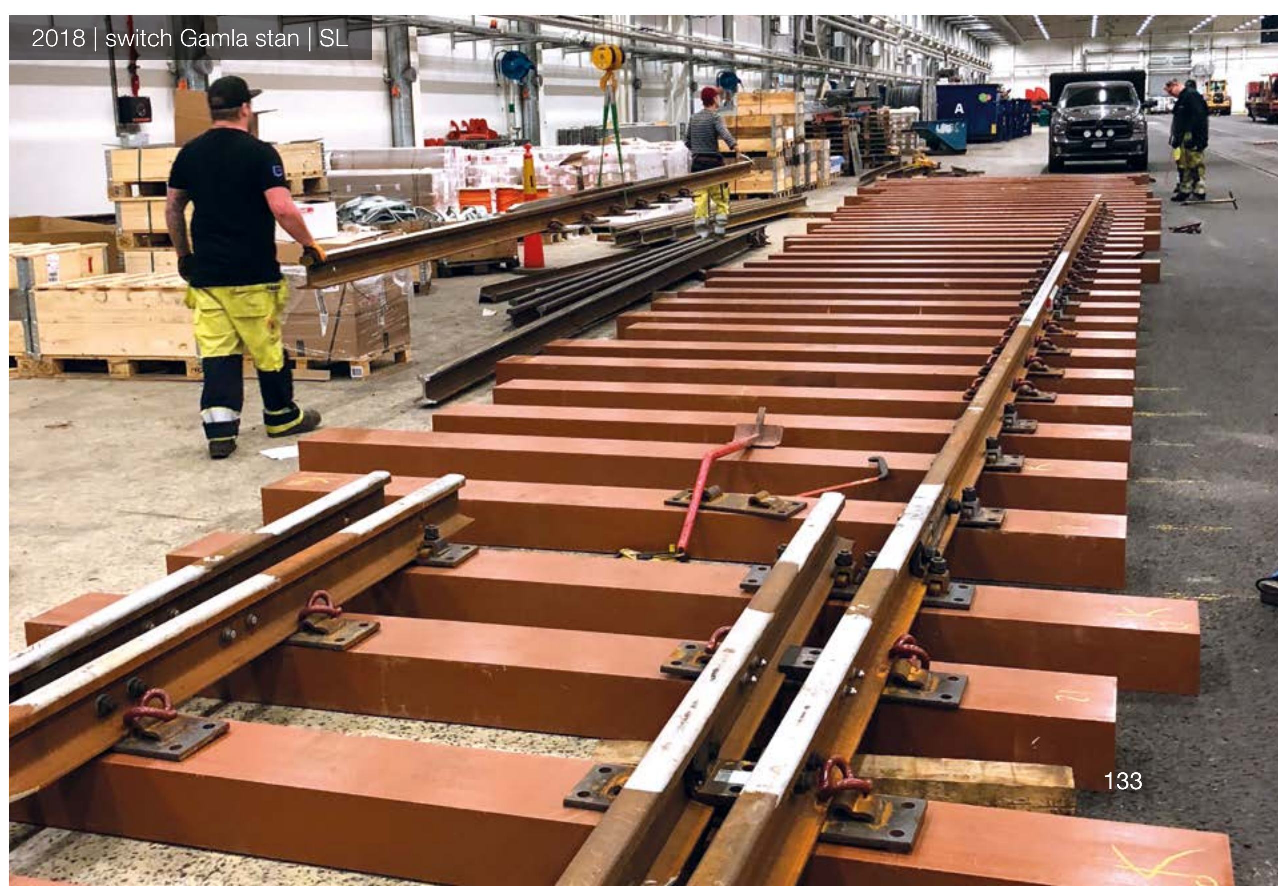
A full replacement of the steel structure and track construction of the bridge has been conducted in Stockholm. This bridge is running over the drinking water lake of Stokholm. In 2017, the first FFU Synthetic Railway Sleepers were installed. All 5 tracks and 9 switches at this bridge were newly constructed with FFU Synthetic Railway Sleepers. More than 2,000 bridge/switch sleepers were installed in total.


2017 | Gamla stan | SL

In 2018 two switches in ballast and in 2019 2 bridges with open steel structures were also installed in Sweden.

2019 | Stockholm | SL

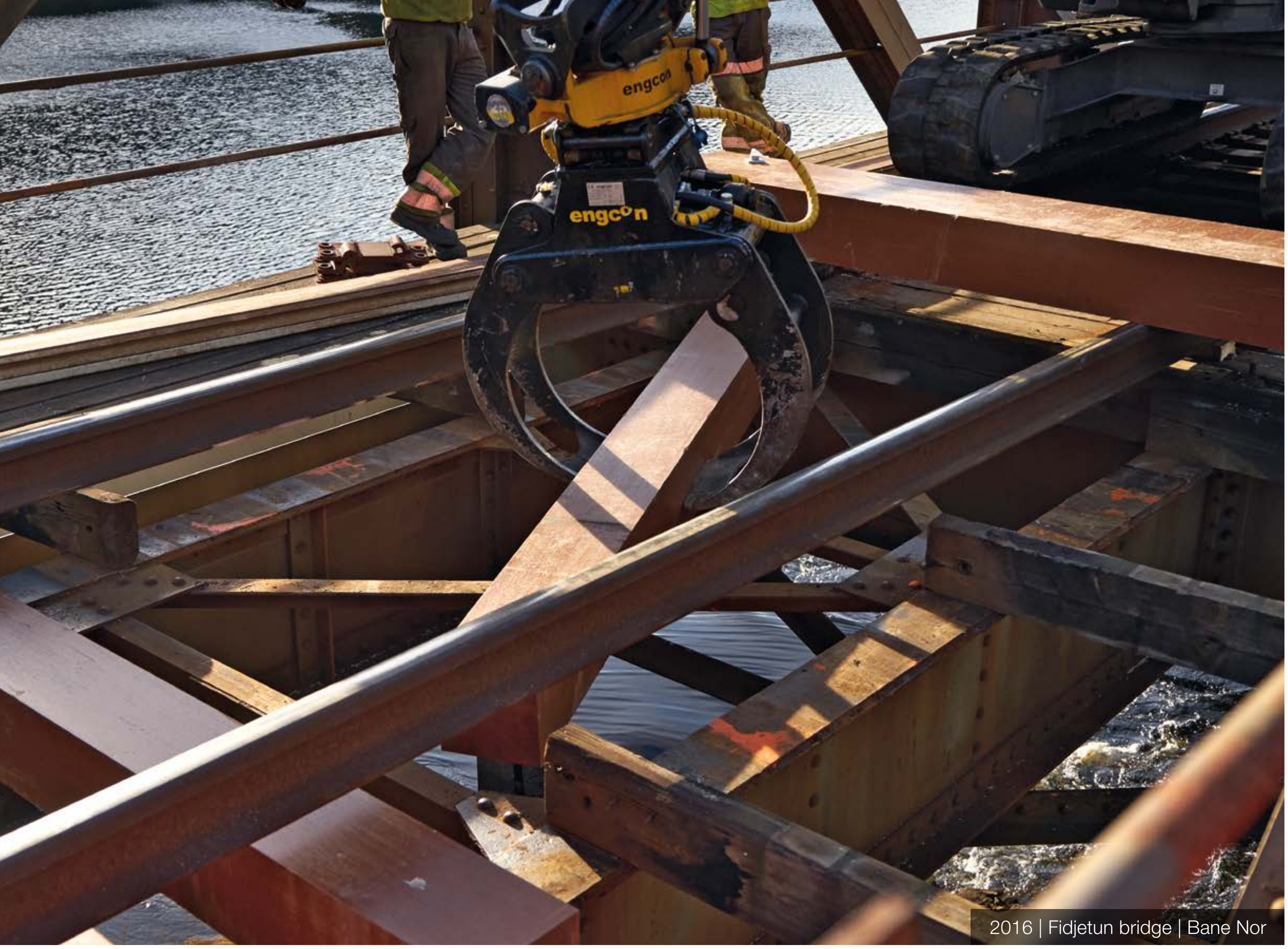
2018 | switch Gamla stan | SL



2016 | Fidjetun bridge | Bane Nor

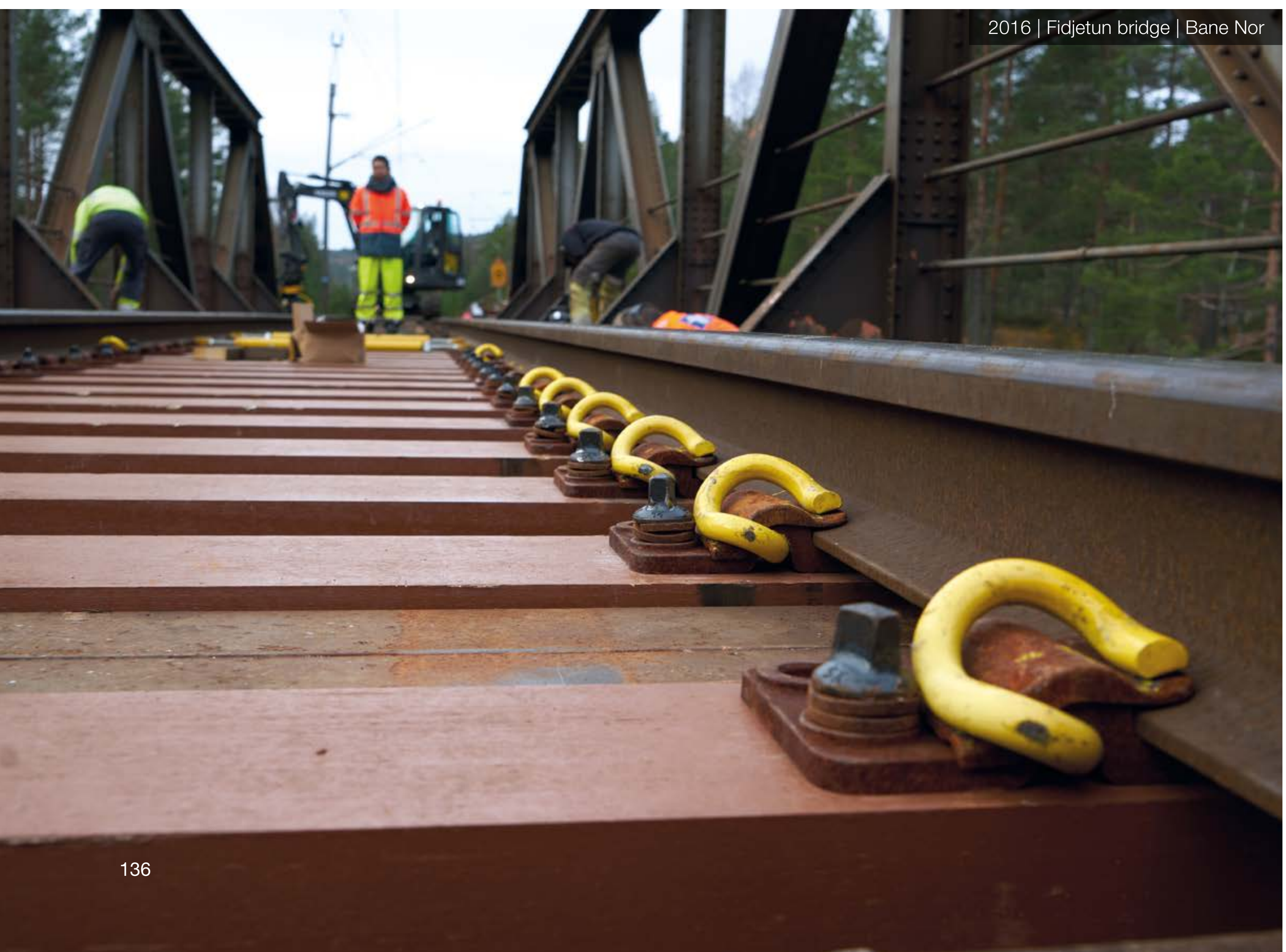
NOR WAY

In November 2016, Norwegian Railway (Jernbaeverket) used FFU Synthetic Railway Sleeper for the first time in Norway and in Scandinavia. The single-track bridge, where FFU Synthetic Railway Sleepers were installed is located on the route Kristiansand, Oslo.



2016 | Fidjetun bridge | Bane Nor

On a Sunday, with a minimum of train traffic, the bridge sleepers were removed during the operation of the track.
Drill holes were prepared on site and old wooden sleepers were removed with a small excavator. Then FFU Synthetic Railway Sleepers were placed on the bridge.



2016 | Fidjetun bridge | Bane Nor


2016 | Fidjetun bridge | Bane Nor

2020 | Pori-Mäntyluoto | Väylä

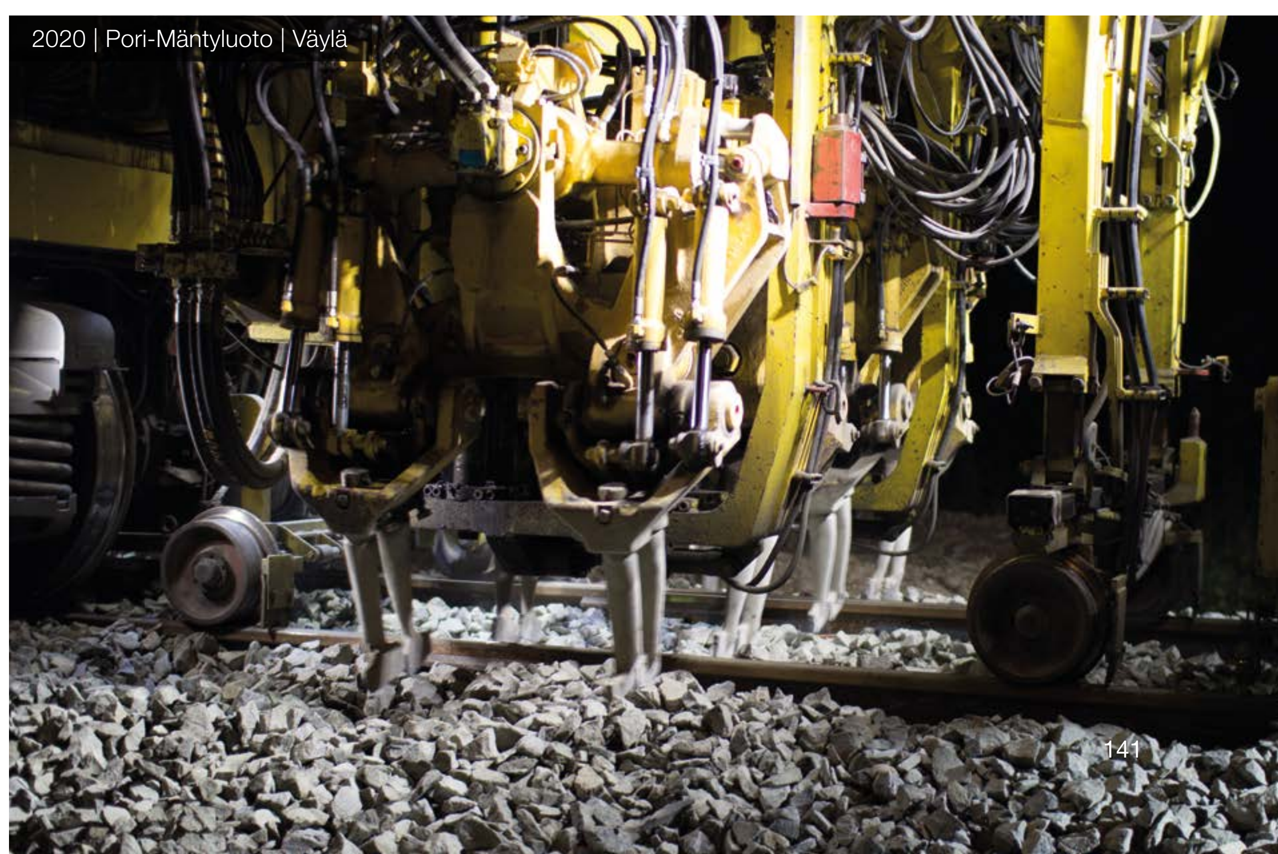
FIN LAND

In 2020, the University of Tampere in Finland measured the performance of FFU under very low temperatures. The strength of FFU remained almost the same at -65°C. The first installation in Finland took place in 2020 by VR Group, a government-owned railway company in Finland.

2020 | Pori-Mäntyluoto | Väylä

In 2020, concrete sleepers and FFU Synthetic Railway Sleepers were installed and tested for a vibration reduction test. Three different widths of FFU were tested - the smallest was 26cm, followed by 30cm and 35cm.

2020 | Pori-Mäntyluoto | Väylä



2020 | Pori-Mäntyluoto | Väylä


10
EW-2
EW-2

NETHER LANDS

Railways in the Netherlands are not maintained by ProRail, who is responsible for the construction, maintenance and management of the Dutch rail network. Instead, it is subcontracted to maintenance contractors. Their railway network is divided into 21 areas. In each area, regular maintenance is entrusted to a contractor. In order to meet the required performance, the contractors use the most economical goods/services while ensuring good performance of the assets.

In 2012, ProRail installed three bridges in Dwarsligger with FFU Synthetic Railway Sleepers. The sleeers at run off/on areas were embedded in elastic materials in order to soften the high excessive load from the rails.

2012 | Dwarsligger | ProRail

2015 | Dudzele | Infrabel

BEL GIUM

Infrabel, a government owned railway company in Belgium, had their first FFU Synthetic Railway Sleeper project in 2015. From the architectural point of view, the sleepers were painted to the same color as the steel construction, so that it becomes a homogeneous design.

2015 | Dudzele | Infrabel

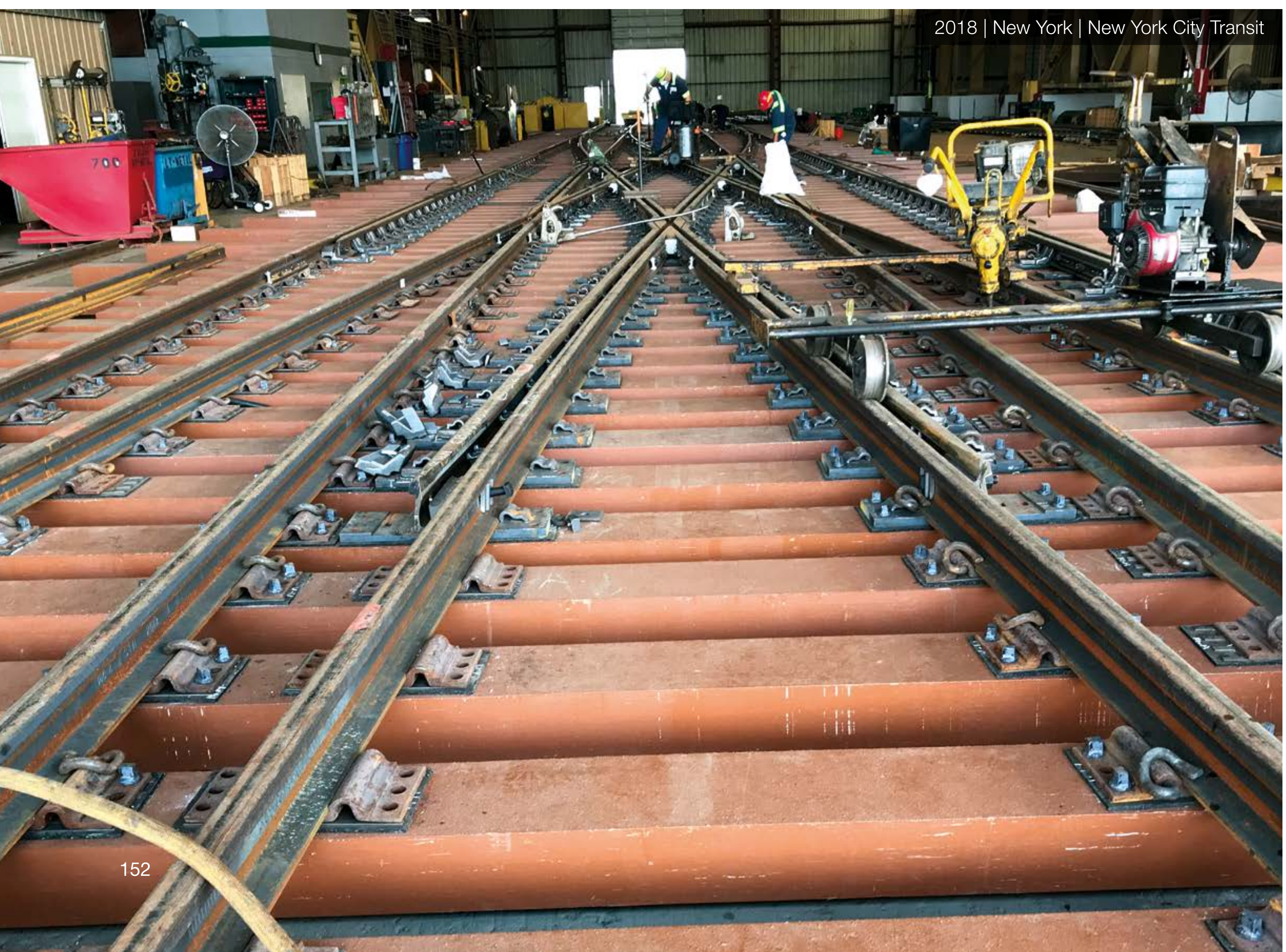
Since it was a moving bridge, weight and longevity were the key factors. In order to reduce the initial cost for materials, a strength calculation was performed, and FFU Synthetic Railway Sleepers with lower height compared with the existing lumbers were installed. The target rail level was achieved by placing FFU height adjustment materials on the sleeper bottom area where in contact with the bridge girders.

2018 | New York | New York City Transit

USA

The railway country with nearly 250,000 km track opened Sekisui the possibility to install first-time high-end technology sleepers from glass fibre and polyurethane in the year 2011 to be installed at a bridge from a private coal mine with an annual tonnage of 40 million tonnes. This was also new for USA customers for synthetic technology at the track with an experiences of 30 years in the field and an expected life time of 50 years.

2018 | New York | New York City Transit



2018 | New York | New York City Transit

In 2018, New York City Transit started to install FFU Synthetic Railway Sleepers to their first project.

2018 | New York | New York City Transit

2012 | Minnamurra Bridge | NSW

AUS TRALIA

FFU Synthetic Railway Sleepers have been installed in Australia since 2010 with its first project at switches. As FFU is strong against thermal expansion, it can keep the track gauge even under the harsh environment with a very large temperature difference.


2013 | City Central 620

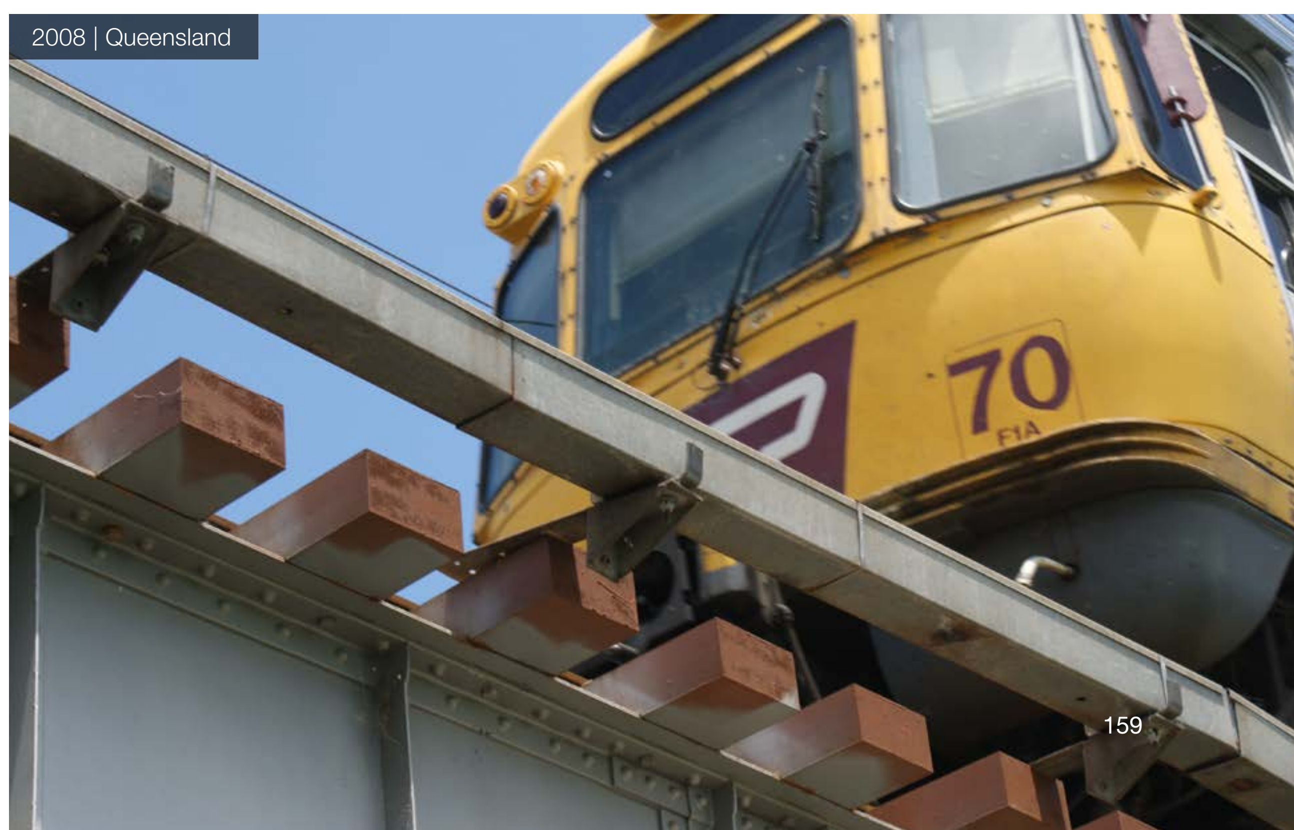
After obtaining type approvals from Australian railway operators and authorities, FFU Synthetic Railway Sleepers are widely installed at switches, and open deck bridges.

Cockle Creek Bridge | NSW

According to Design of Transom issued by Transport for NSW in 2018, depending on the track design and condition, FFU100 (1,000kg/m^3) sleepers are installed at open deck bridges as replacement of hardwood sleepers.

2011 | Hornsby Junction Sydney

2008 | Queensland



2018 | Cilame - Sasaksaat Bridge | PT Kereta Api Indonesia

INDO NESIA

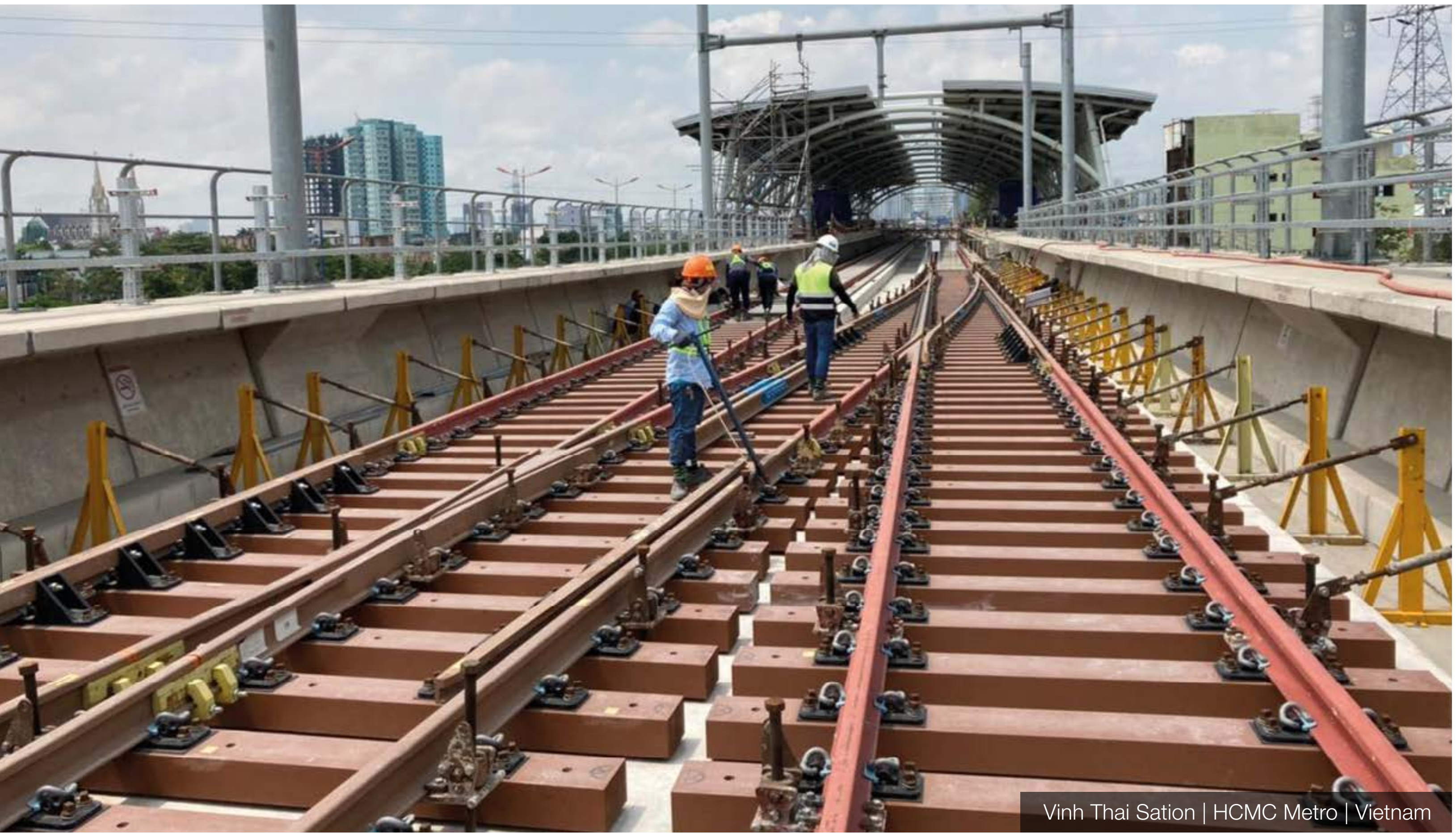
The successful result of trial installation in 2012 motivated PT. Kereta Api Indonesia, Indonesian Railways Company, to upgrade their rail infrastructure with FFU Synthetic Railway Sleepers. Since 2018, more and more of the technology has been installed at their bridges.

2018 | Cimahi Chimihdi Bridge | PT Kereta Api Indonesia

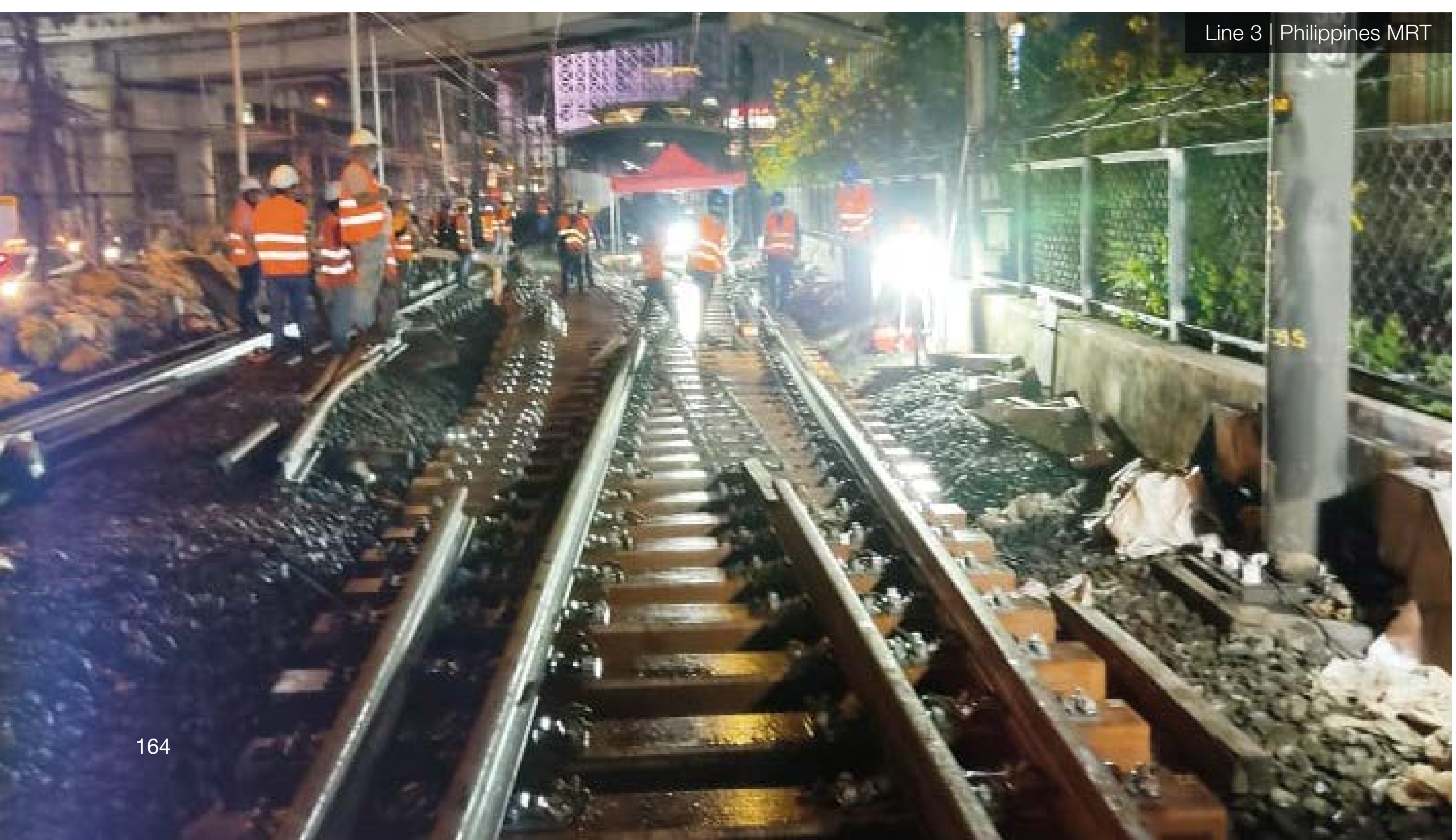
In Indonesia, the service life of wooden sleeper is around 10 years in general due to its high temperature and humidity, so the railway sleepers need to be replaced frequently even though the work in high places is very dangerous and costly. The long service life of FFU Synthetic Railway Sleepers can achieve the significant reduction of replacement work along with better stability and safeness of the track.

2018 | PT Kereta Api Indonesia

Ho Chi Minh City Metro, the first metro network in Vietnam, designs its track as ballastless for the ease of maintenance. FFU Synthetic Railway Sleepers have been installed at turnout sections. FFU can be nailed and screwed at construction sites for fine adjustment, so it achieves better workability of construction and greater longevity of the track.



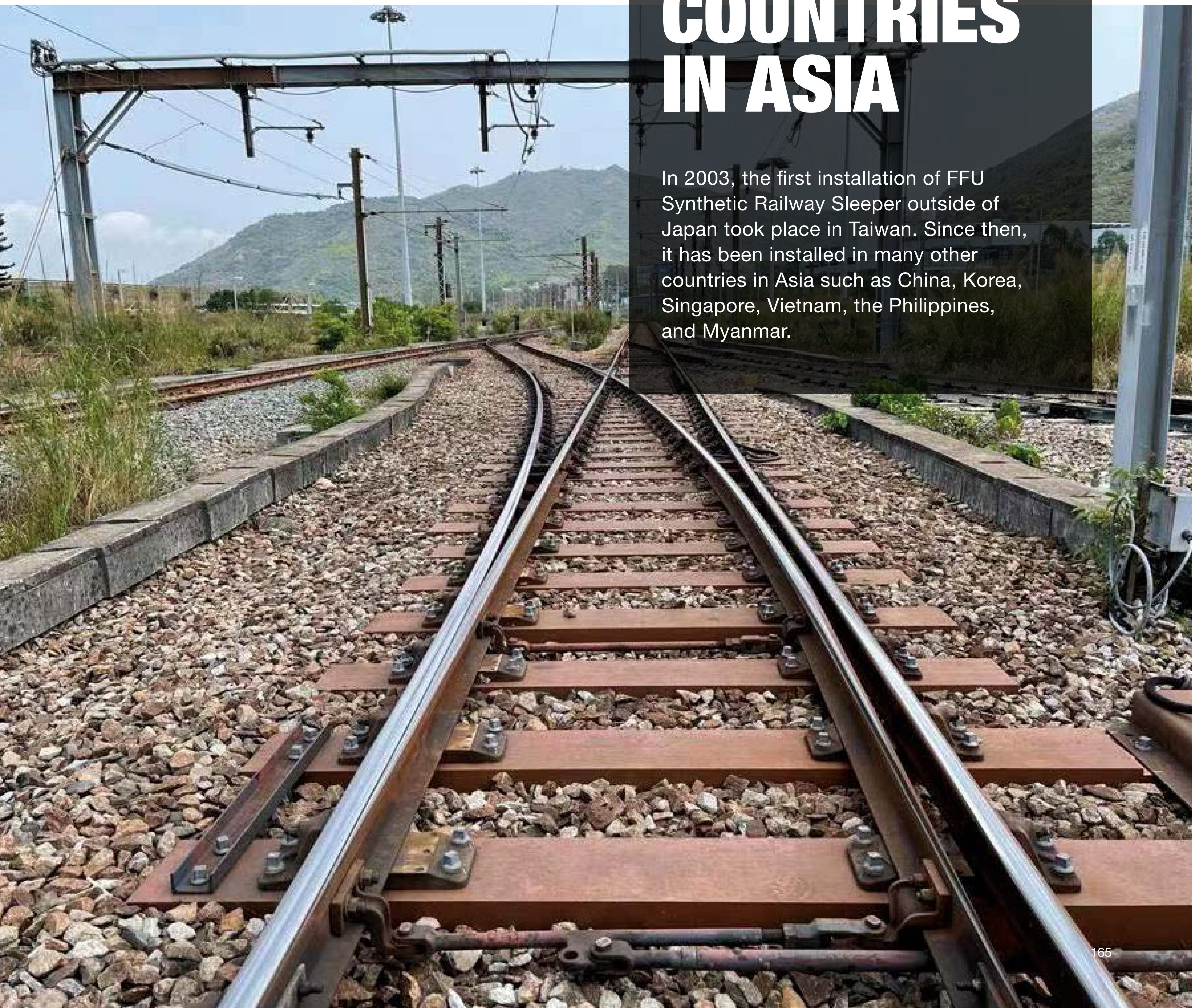
Vinh Thai Sation | HCMC Metro | Vietnam



Line 3 | Philippines MRT

OTHER COUNTRIES IN ASIA

In 2003, the first installation of FFU Synthetic Railway Sleeper outside of Japan took place in Taiwan. Since then, it has been installed in many other countries in Asia such as China, Korea, Singapore, Vietnam, the Philippines, and Myanmar.



2014 | Touhokushinkannsen_hakodata station

Special thanks to all the railway operators, authorities, universities, contractors, and our partners who have believed in this FFU technology and supported us in the past 40 years. We will continue our best to work closely with our clients to find the best solution for their track.

SEKISUI Railway Technology Team

SEKISUI CHEMICAL CO., LTD.

A new frontier, a new lifestyles.

SEKISUI CHEMICAL Group's Principle comprises elements such as our Corporate Philosophy, Group Vision that expresses an ideal form aimed for by the Group in the medium to long term, and our concrete Management Strategies to realize the Group Vision. Based on „Group Principle", and by the unified efforts of all employees of the group we aim for a corporate group which is sustainable for the next 100 years.

The unified global message is „A new frontier, a new lifestyle."

The Group Slogan supports the management strategies drawn up by the SEKISUI CHEMICAL Group.

SEKISUI CHEMICAL Group aims to contribute to society through its business activities, and has embodied this ambition in its Corporate Philosophy called the „3S Principles".

Our Group Vision clarifies that we will endeavor to improve the lives of the people of the world and the Earth's environment, while defining residential and social infrastructure creation and chemical solutions as areas of society on which to focus our efforts.

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