

Iarnród Éireann chooses synthetic timber for cost savings

Iarnród Éireann is currently undertaking a project to replace the timber waybeams on the 135m long 5-span Shannon River Bridge UBE16 in Limerick.

Photo 1. General view of Shannon River Bridge UBE16 in Limerick.



A “Waybeam” is the term for a railway sleeper supporting the rails by running longitudinally under the rail. Made from timber, waybeams were once commonplace at bridges in Ireland where the lightweight rail support assembly kept the cost of bridge construction down. Many have been eliminated during upgrades over the years to facilitate higher axle loads, higher running speeds and to reduce maintenance costs. There are now only 4 waybeam bridges remaining on the Iarnród Éireann operating network.

When new, timber waybeams are treated with a preservative, however, over time they become susceptible to rot. A detailed inspection of waybeams is carried out annually to ensure the security of bolts, packings and other fixings as well as to assess the general condition of the timber. An important part of this annual inspection is to hammer tap the timber whilst listening for any change in pitch. If a dull sound is detected this is indicative of rot in the timber. At bridge UBE16 in Limerick rot was detected by the hammer tap inspection in 2015. There was little indication on the top surface of the timber of an internal problem and this is why the hammer tap inspection is so important.

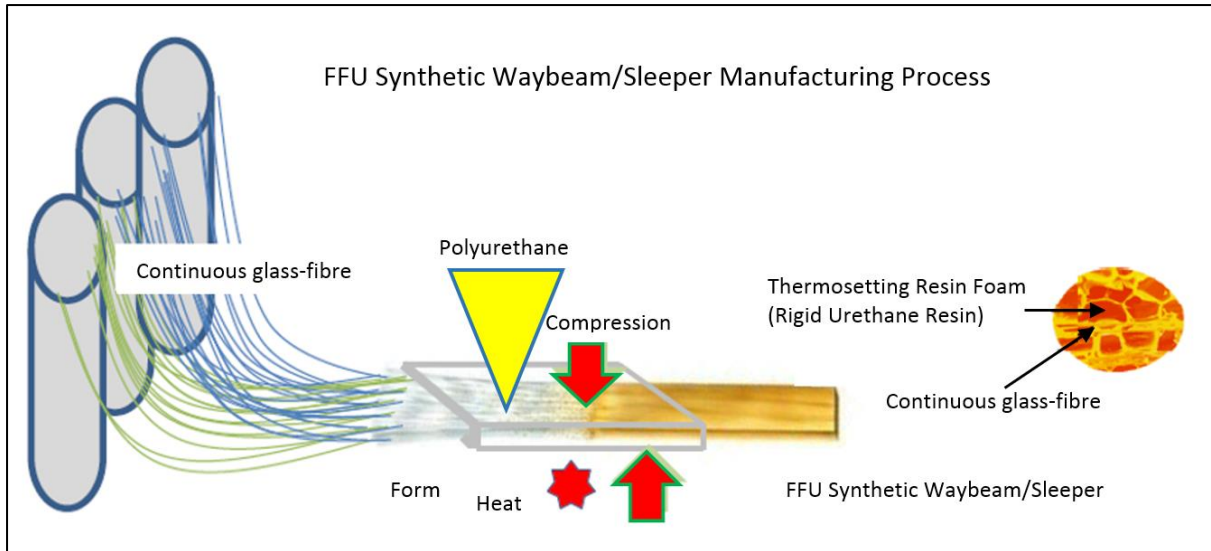
Photo 2. View showing rot in timber waybeam removed from UBE16. Note how there is no visual indication on the top surface of this deterioration.



Having identified the timber waybeams were approaching a condition where they would have to be removed, an engineering appraisal of options for replacement was prepared. An appraisal must consider an appropriate range of options to ensure that Iarnród Éireann meets its statutory responsibilities with due regard to Efficiency, Economy and Safety. Five different options were identified and appraised in terms of whole-life costs and the cost/disruption for installation. Bridge UBE16 is on the line between Limerick and Ennis. It is a single track line with bi-directional operation. Therefore there is no alternative track that could be used if the option chosen requires a period of line closure. In terms of costs, keeping a line open is obviously favourable as it will avoid the cost of replacement buses and avoid the loss of revenue if passengers choose not to travel as a consequence. The appraisal of the five options for UBE16 identified a valuable opportunity to bring significant cost savings during the lifetime of the track system by choosing renewal of the timber waybeams in a synthetic material. A specification was prepared and following a tender process a Fibre-reinforced Foamed Urethane (FFU) material was selected.

FFU is a material developed for the Japanese Railways and introduced in Japan in the 1980s. FFU is much more durable than natural timber and most importantly does not rot. It has a design life in excess of 50 years which is in stark contrast to hardwood timber's 20 years. Choosing FFU eliminates 2 future renewals that timber waybeams would require by 2067. Also, since FFU does not absorb water, corrosion of steel at the transverse supports and at the fixings will be much reduced. Less corrosion means less structural maintenance required to the bridge. Another advantage of the FFU material over timber is that boreholes can be repaired using a resin repair system should it be required.

To manufacture FFU, glass-fibre strands are drawn through a pulling device and soaked in polyurethane. It is then cured at high temperature, resulting in a high-grade, pore-free material.



The waybeam system at bridge UBE16 in Limerick is not continuously supported, but is supported transversely at intervals. Therefore the specification for the synthetic waybeam material required it to have similar shear and bending resistance properties to the timber it is replacing. Table 1 shows a comparison of FFU properties with that of Beech which is a typical hardwood timber.

Table 1: Comparison of Beech and FFU sleeper material properties

Properties		Unit	Beech new	FFU synthetic sleeper		
				New	10 years	15 years
Density		[kg/m ³]	750	740	740	740
Bending resistance		[kN/cm ²]	8	14.2	12.5	13.1
Bending modulus		[kN/cm ²]	710	810	800	816
Compressive resistance		[kN/cm ²]	4.0	5.8	6.6	6.3
Shear resistance		[kN/cm ²]	1.2	1.0	0.95	0.96
Hardness		[kN/cm ²]	1.7	2.8	2.5	2.7
Impact bending resistance	+ 20°C	[J/cm ²]	20	41	-	-
	- 20°C	[J/cm ²]	8	41	-	-
Water absorption		[mg/cm ²]	137	3.3	-	-
Electrical insulation resistance	Dry	[Ω]	6.6x10 ⁷	1.6x10 ¹³	2.1x10 ¹²	3.6x10 ¹²
	Wet	[Ω]	5.9x10 ⁴	1.4x10 ⁸	5.9x10 ¹⁰	1.9x10 ⁹
Rail spike extraction force		[kN]	25	28	28	23
Rail screw extraction force		[kN]	43	65	-	-

Photo 3. Shows waybeam removed at UBE16 illustrating how the waybeam is supported at intervals.



Photo 4. The FFU waybeams were manufactured in Japan by Sekisui Chemical Company Ltd and delivered to the Iarnród Éireann depot in Mullingar during August.



Photo 5. Renewal of the waybeams with FFU commenced during night working in September.



Photo 6. The FFU waybeams handle similarly to timber waybeams. The FFU material can be machined or worked using the same methods and tools as those used for timber sleepers.



Logistically, this project posed some challenges as well as opportunities. FFU is only produced in Japan, meaning that the waybeams required were manufactured in Japan by Sekisui Chemical Company Ltd before being shipped to Ireland in advance of the project start date in September 2017. To keep the Limerick to Galway line open and operating as usual, the FFU waybeams are being installed at night. At the end of each 8-hour shift the track is checked and returned in a serviceable condition for trains to run in the morning. By choosing to introduce a new material for the first time on the network, the FFU material and its use as a waybeam at UBE16 needed to pass Iarnród Éireann's vigorous Safety Approval Process. This was completed in stages between January and July 2017. Since the transverse supports under the waybeam are generally inaccessible unless the waybeam is removed, the project has provided an opportunity to undertake minor steel repairs to these areas and rivet replacement. The project plan is to change a waybeam every 3 nights following steel repairs. All works, including track protection, waybeam installation and steel repairs are being carried out by in-house IÉ work crews.

During the Safety Approval for the new material it was identified that additional safety precautions were required for working with the FFU material compared to natural wood. In particular:

- Because FFU contains glass fibres, PPE is required to protect against dust and fine particles generated when drilling or sawing. Disposable dust masks, overalls, gloves, and safety goggles should be worn to keep dust and fine particles away from the body and respiratory passages. An industrial vacuum cleaner is used when drilling on site to capture the dust and swarf generated.

- To prevent glass fibres in the FFU synthetic material from melting and tools becoming stuck, the RPM of the equipment must be controlled so that the FFU material does not become hot.
- FFU synthetic material is a closed pore material. Water and/or low temperatures can lead to the surface of the material posing a slip hazard. Staff should avoid walking on the FFU material unless it has been treated with an anti-slip coating intended for walking on. As the waybeams in their final position are longitudinal and cannot be walked upon, there is no requirement for anti-slip coating on them.

Photo 7. PPE required is disposable dust masks, overalls, gloves, and safety goggles. Note also the industrial vacuum cleaner used to capture the dust and swarf from drilling.



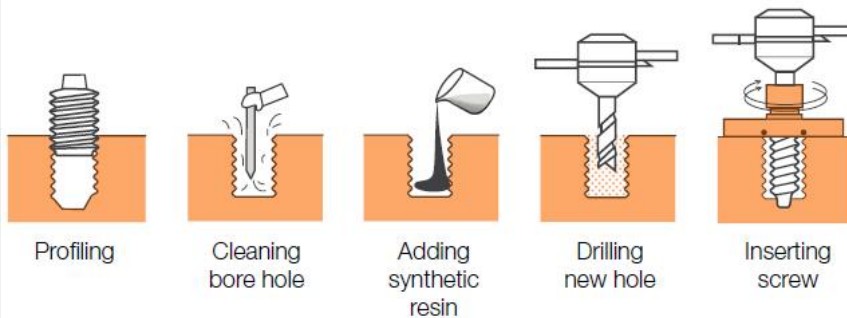
Repairing bore holes

Repair method with synthetic resin only

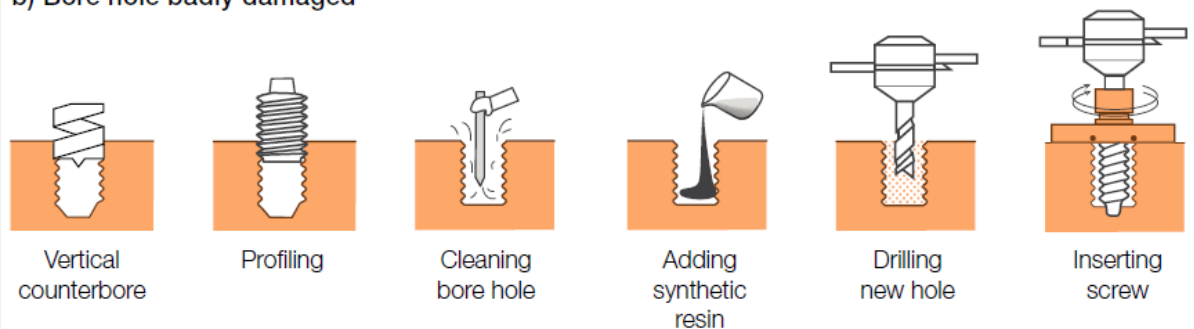
Old and new bore hole at the same spot or overlapping

If only synthetic resin is used for repair, as shown in the work steps below, the repaired bore hole can be worked at the earliest **after a curing time of 30 minutes, similar to FFU synthetic wood.**

a) Bore hole not badly damaged



b) Bore hole badly damaged



Summary

Iarnród Éireann engineers identified an opportunity to introduce Synthetic Fibre-reinforced Foamed Urethane waybeams into the rail network. This project is achieving significant cost savings which will continue during the lifetime of the track system. The serious maintenance issue of timber rot has been eliminated by the introduction of this new material. There is potential to use FFU and other synthetic materials in future track works. The installation of the FFU waybeams at bridge UBE16 in Limerick is on target to be completed in December 2017. The work has been completed with no disruption to normal train services.