“Noise barrier” directly on the rail

Calmmoon Rail is a noise-abatement device which is attached to the web of a rail. Its effect is comparable to that of a noise-protection wall. It was successfully tested in 2009 on two projects with the Austrian Federal Railways (ÖBB, Fig.1). It has now also been approved by the German Federal Railway Authority (EBA) in April 2010.

Robert Koch (1843–1910) left his mark on history as a German doctor of medicine, microbiologist and Nobel-Prize winner. He used to say that the day would come when human beings would find themselves combating noise with just as much bitter determination as had gone into the fight against cholera and the plague.

Those in positions of authority in the individual countries are enacting laws and adopting regulations targeted on reducing noise pollution, with the aim of contributing to lasting public welfare. In the field of railway infrastructure, the way of attaining such goals in the medium term is to apply new technologies and to make sure that all stakeholders play an active part. Permanent-way engineers, material scientists and rolling-stock manufacturers are all called on to reduce the occurrence of noise at source. By pooling their knowledge and working together, they ought to be looking for the optimum way of combating noise sources, which, in the final analysis, will be beneficial for everyone concerned.

Applying noise-abatement measures to rails – in other words using new technologies to reduce the emission of noise from rails at source – is one piece in a much larger jigsaw puzzle, representing the whole process. Alternatively, do we as railway passengers of the future wish to be transported through conduits, hemmed in by noise-protection walls, and do we want to create transport systems that “dissect” nature and the countryside?

Dipl.-Ing. Dr. techn.
Günther Koller

CEO

Koocoo technology & consulting GmbH, Vienna (Austria)

office@koocoo.eu

Fig. 1: Installing Calmmoon Rail on the test track in Deutsch-Wagram (source: Matsuda)

1 The Calmmoon Rail system

Calmmoon Rail is a noise-abatement system for the webs of rails forming railway tracks. Sekisui developed it especially for this purpose in 2005. It is a system that works like a minute noise-protection wall installed directly on the web of the rail. Its declared purpose is to achieve a perceptible reduction in the volume of noise emitted from rails without impairing their functions as technical items of railway equipment, in other words without detracting from their reliability and without constituting an obstacle to their maintainability.

Calmmoon Rail is built up of a steel section shaped to match the rail plus a layer of Calmmoon and a layer of polyethylene foam with strong noise-absorbing properties. Calmmoon itself is a composite material, comprised of a 0.8-mm-thick layer of synthetic resin and a 0.5-mm-thick metallic substrate, and was developed by Sekisui in 2002 for reducing structure-borne noise (Fig. 2). When the layer of synthetic resin oscillates it converts vibration energy into heat, which has the effect of reducing noise. These two layers are placed on the web of the rail and also on the bottom surface of its base. The rail is thus totally encased in noise-absorbing material, with the exception of its head, those parts of its base that coincide with the sleepers and parts of the web and base immediately adjacent to the rail fastening. Two safety stirrups per rail occupying the spaces between the sleepers ensure that the elements will remain securely fastened for a long time.

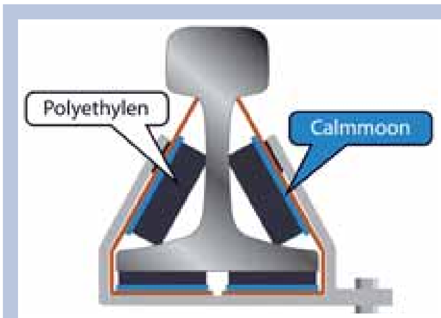

Fig. 2: System diagram of Calmmoon Rail (source: Büro Pani)

The technology used for Calmmoon Rail differs from the vast majority of noise-absorbing or damping systems available on the market for application on the web of a rail, in that it does not incorporate any form of concentrated mass attached to the rail for reducing vibrations and oscillations. The mass of the Calmmoon Rail noise-protection system is around 4.5 kg per running metre of rail, but this varies somewhat depending on the profile of the rail. Another of the aims of Calmmoon Rail is to influence the physical properties of rails in service as little as possible.

One of the effects of this is that Calmmoon Rail does not have a big impact on the de-

Fig. 3: Calmmoon Rail on a railway bridge with an open steel structure (source: the author)

Fig. 4: Calmmoon 1.3-mm noise-protection sheeting (source: the author)

cay rate of the rail system. The decay rate is a parameter that describes the reduction in the vibrations per running metre of rail [dB/m] relative to each of the individual third-octave bands. A high decay rate signifies a “good” rail with low noise emission through it, whereas a low decay rate signifies a rail with very strong vibrations that persist for a long time, thereby emitting a great deal of noise.

Provided the work site is guarded by the necessary safety lookouts (“flagmen”), Calmmoon Rail can be fitted to railway tracks quickly and simply while trains continue to run normally. Given that the actual spaces between sleepers deviate in practice from the theoretical target values, the Calmmoon Rail elements are manufactured in different lengths (between three and five of them). These can be attached to the rail quickly. The differences between the lengths of the spaces between the sleepers are compensated for by overlaps above the sleepers, which results in uninterrupted noise-absorbing material along the rail web. Dismantling the Calmmoon Rail elements is as fast as installing them, and that may be necessary, for instance, to allow an old rail to be removed and a new one to be laid. Cables running along the base of the rail are not affected by the installation of Calmmoon Rail. It may be that the railway infrastructure operator wants to have the rail type immediately recognisable at any time. If so, that can easily be achieved by labelling the outer skin of the Calmmoon Rail system with this information.

2 Calmmoon Rail measurements during the Hainburg project

Over a period of up to four months in 2009, the acoustics of two different projects involving Calmmoon Rail were observed by psiA, an independent engineering and consultancy company. This first project involved a system test on three bridges in the town of Hainburg (Lower Austria) and was commissioned by the Austrian Federal Railways (ÖBB). At this location, Calmmoon Rail was used on railway bridges with an open steel structure and in the zones between, where there were ballasted tracks.

The test was divided up into several stages. The first of these involved a “zero series” of measurements of the infrastructure as it was before any change was made. The next stage in the Sekisui test zone consisted in removing the existing bridge timbers and replacing them with new made-to-measure “timbers” made of FFU synthetic wood. The ÖBB had computed a new gradient for the section of track concerned, including the three bridge projects, and wanted to be sure that this had been meticulously respected at the end of the conversion work. Every new bridge timber to be installed had its own height. These new synthetic timbers were prefabricated in the factory with millimetre accuracy and then delivered in such a way that the customer was indeed able to confirm that the new gradient corresponded to the specification. In addition, the horizontal drill holes for fastening each of the timbers with the correct inclination were also prepared in the factory.

The next stage, which lasted two weeks, consisted in the noise measurements as such. For that purpose, Calmmoon Rail was installed as a noise-abatement device on the rail webs (Fig. 3). The effect of this measure was studied during the next stage, which also lasted for a period of two weeks. This was followed by covering around 60% of the longitudinal girders in the bridge’s steel framework with 1.3-mm-thick noise-

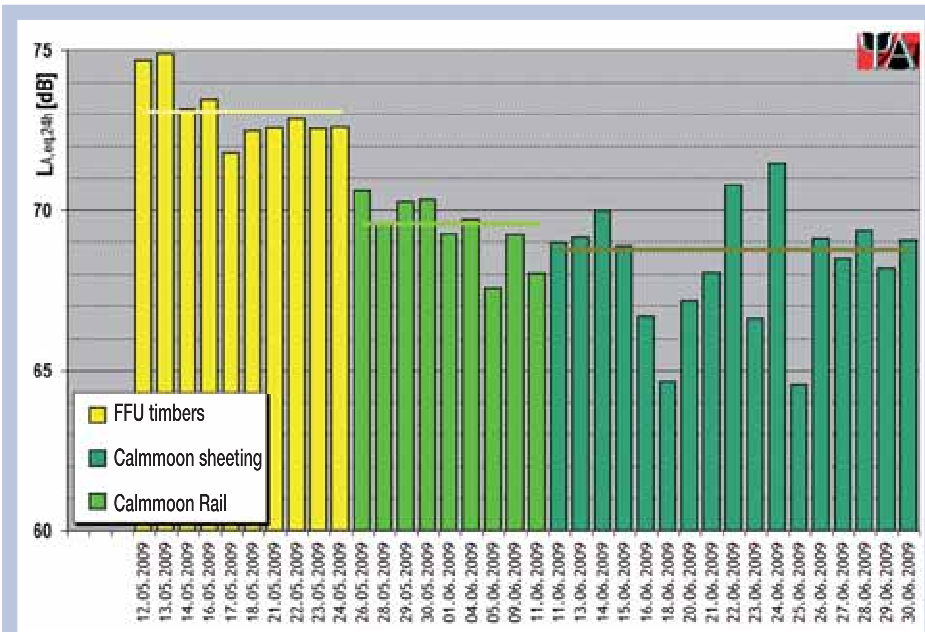

Fig. 5: A-weighted level of acoustic events measured near Hainburg (source: psiA)

absorbing Calmmoon sheeting, which was glued in place (Fig. 4). This was followed by another series of measurements lasting two weeks.

Figure 5 shows the A-weighted level of acoustic events (Lp,AE) for an ÖBB "Talent" multiple unit [1]. Since it is not the case that every day an identical number of trains with the same number of (differently) noisy axles pass within a given unit of time (such as a calendar day), it is logical that the LAE values should differ for each 24-hour period. If, however, the measurements are continued for a sufficiently long period, it is possible to establish a mean level of noise nuisance or the mean reduction in it. The figure shows clearly that the installation of Calmmoon Rail alone brought down the noise nuisance of the system as a whole by 3.5 dB(A).

Fig. 6: Calmmoon Rail installed on ballasted track near Deutsch-Wagram (source: Matsuda)

Category of train	Quality of wheel	Without Calmmoon Rail	With Calmmoon Rail
CD Pendolino (class 680)	Very smooth	25	48
ÖBB S-Bahn EMU (class 4024 "Talent")	Very smooth	30	59
ÖBB double-deck regional passenger rake (class 80-33)	Smooth	188	358
ÖBB S-Bahn EMU (class 4020)	Rough	498	934
Freight trains	Very rough	157	318
Total number of trains measured		898	1717

Table 1: Number of passing trains measured at Deutsch-Wagram and the quality of their wheels [1]

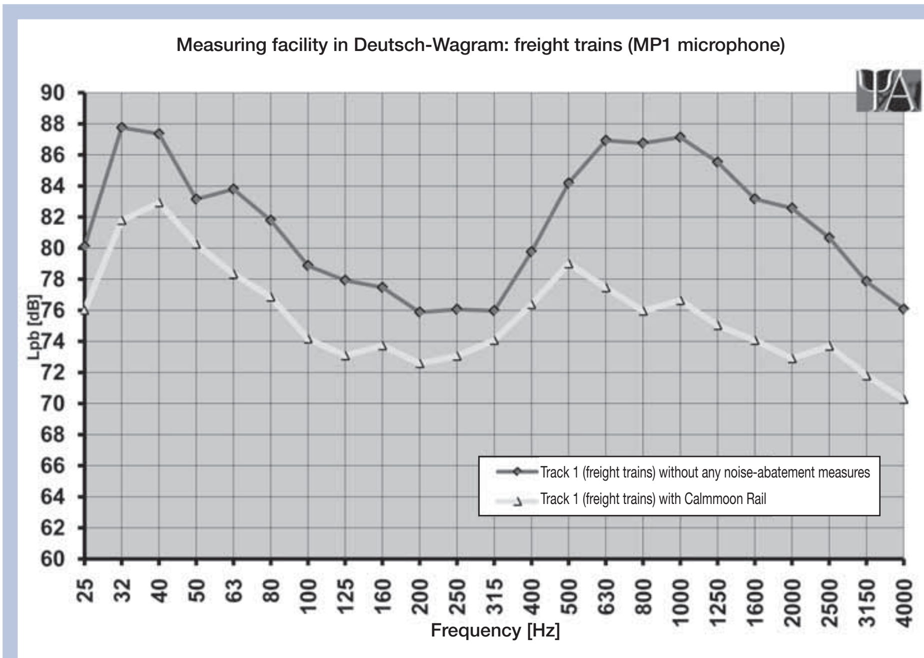

Fig. 7: Mean unweighted spectrum of freight trains passing at 80 km/h (source: psiA)

3 Measurements during the Deutsch-Wagram project

The second Calmmoon Rail project was commissioned by Sekisui along with the ÖBB using the permanent infrastructure measuring facility in Deutsch-Wagram (Lower Austria) on a railway line known as "Nordbahn". This measuring facility was set up in 2006 and has been used since then for measuring the noise and vibrations caused by all the trains running on track 2.

Calmmoon Rail was installed over a length of about 30 m on track 1 (one of the through tracks) at kilometre 14.6 (Fig. 6). The permanent way there is comprised of ballasted track with concrete sleepers, with a mean spacing of 60 cm, and type-S 49 rails. The noise caused by passing trains and the reduction achieved was studied and quantified in accordance with the provisions of the ÖN EN ISO 3095 standard.

A measuring microphone was positioned at a height of 1.2 m above the contact surface of the rails at a distance of 7.5 m from the axis of track 1. The microphones belonging to the permanent measuring facility on track 2, which are located 11.5 m from the axis of track 1, were used to record additional measurements. Thanks to the inbuilt redundancy of the two microphones, their measurements can be used for cross-checking and plausibility checks. All of these microphones are, of course, weatherproof. Additional equipment was installed to supplement their measurements, namely two wheel sensors, delivering axle signals, and accelerometers for the vertical and horizontal accelerations of the rails. Meteorological records were also kept in addition to the records of the acoustic parameters.

The data recording for each train included the precise time at which each of its axles passed through the measuring cross-section. Parallel measurements were also recorded of the noise level, the acceleration values of the rails and sleepers and the axle signals from the inductive wheel sensors. The axle signal (= axle position) was taken as the basis for correlating the emissions measured (noise and acceleration values) with the momentary positions of each individual wheel or the sequence of a bogie. The signal patterns produced by the axles were compared with an internal train database to determine the category of each train (such as freight train, passenger train, light locomotive, and so on).

The following parameters were measured and analysed: noise level caused by each category of train as a function of passing speed, noise-level spectrum of each passing category of train and change in the A-weighted passing noise level of each category of train. The decay rate was not included in this particular study, since it was already known from the earlier Hainburg test that Calmmoon Rail had no influence on it.

The “zero series” of measurements was made over a period of six weeks. After that, Calmmoon Rail was safely installed, without interrupting the railway operation, which took half a day. The next stage was the continuous measurement of the system over a period of twelve weeks, during which the effects of 2615 different trains were recorded. Table 1 presents a breakdown into the various types of train studied. Finally, Calmmoon Rail was removed, which took very little time, again without interrupting the normal railway operation.

Figure 7 show the mean values for the linear third-octave spectra of freight trains passing at 80 km/h. Freight trains are representative of railway vehicles with very rough wheels. What is striking is that the values for the “with Calmmoon Rail installed” state are very significantly below those for the same rails with no noise absorption. This difference is in the range of 2–6 dB for the frequency band from 25 to 400 Hz, reaching a maximum of up to 11 dB for the frequency band of 800 to 1000 Hz.

Figure 8 shows the reduction in the noise level at a distance of 7.5 m from the track and at a height of 1.2 m above the contact surface of the rails. It can be clearly seen that the reduction fluctuates between approximately 2 and 4 dB(A). As a general trend, it emerges that the greatest effect on rails equipped with Calmmoon Rail is achieved for rolling stock with rough or very rough wheels running at slow speeds.

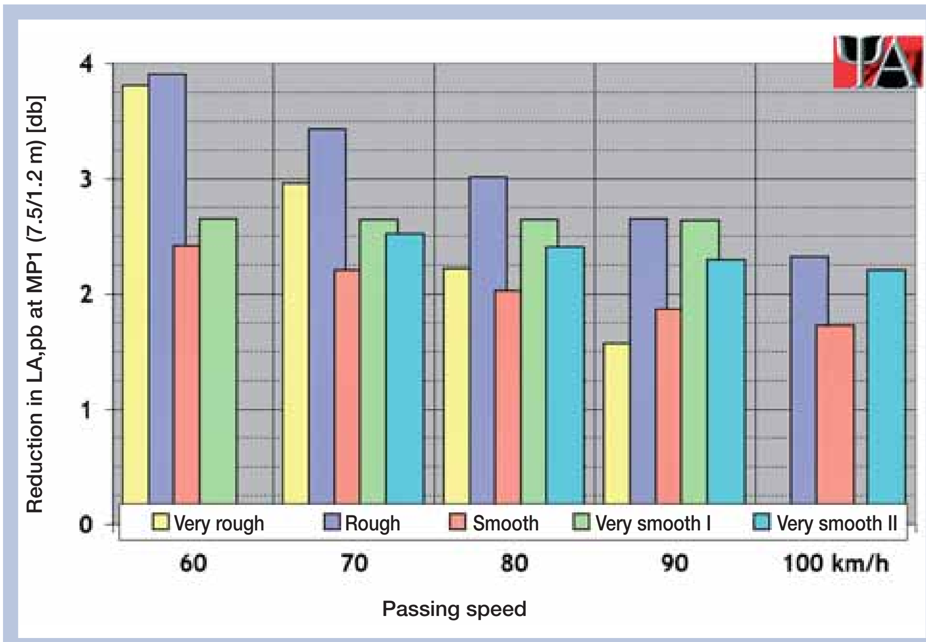

Fig. 8: Reduction in the A-weighted noise level of passing trains with different degrees of wheel roughness (source: psiA)

4 Concluding summary

The Calmmoon Rail system for application to rail webs for reducing the emission of noise was used for two projects in Austria in 2009 and tested for several months. The results show that the level of air-borne noise was reduced by between 2 and 4 dB(A) through the use of Calmmoon Rail. For freight trains running at 80 km/h, a noise reduction of up to 11 dB in the frequency band of 800 to 1000 Hz can be seen in the mean unweighted spectrum caused by passing trains.

Having obtained these test results from Hainburg and Deutsch-Wagram, Sekisui felt encouraged to apply to the German Federal Railway Authority (EBA) for an approval for the Calmmoon Rail web-mounted noise-protection system to undergo operational tests on the railway infrastructure in Germany. The EBA issued this approval in April 2010.

Reference

[1] Report of the psiA study (in German), Dr. Kalivoda, September 2009