Damping down noise

Dr **Martin Toward**, Dr **Giacomo Squicciarini** and Professor **David Thompson** of the Institute of Sound and Vibration Research share their case study on the effects of a track renewal on noise

Railway noise is increasingly becoming a source of concern to line-side residents. This is not only the case for new lines but also for existing lines where increased traffic or changes to the rolling stock or track may lead to increased noise and resultant complaints.

Some anecdotal accounts have reported increased noise levels subsequent to a track renewal; the reason for this increase is unclear. In this study, as part of the EPSRC funded TRACK21 project, we made measurements and predictions of noise at a site in Fishbourne in Sussex to improve understanding of this phenomenon.

While at very high train speeds aerodynamic noise is important, and at low speeds traction noise can contribute, at most speeds, rolling noise is the dominant source of environmental noise from trains. The principal excitation mechanism of rolling noise is the surface unevenness (or 'roughness') of the rail and wheel. This unevenness causes vibration of the wheel, rail and sleeper, which in turn is radiated as noise.

Commonly, the noise emitted during a train pass-by is measured directly, *e.g.* using a sound level meter. These measurements can be very useful in determining the overall level and also the frequency composition of the noise, but from these it is not easy to separate out the individual contributions of the rails, wheels and sleepers to the noise. Therefore, when a change in the level or the characteristics of noise at a particular site is recognised it is often difficult to identify the cause of this change from noise measurements alone.

Prediction methods have been developed over recent years to provide this fundamental understanding of railway noise, one of the most widely used of which is TWINS. This model allows the noise contributions of the rails, wheels and sleepers to be predicted from a number of measurable parameters related to the track and vehicle.

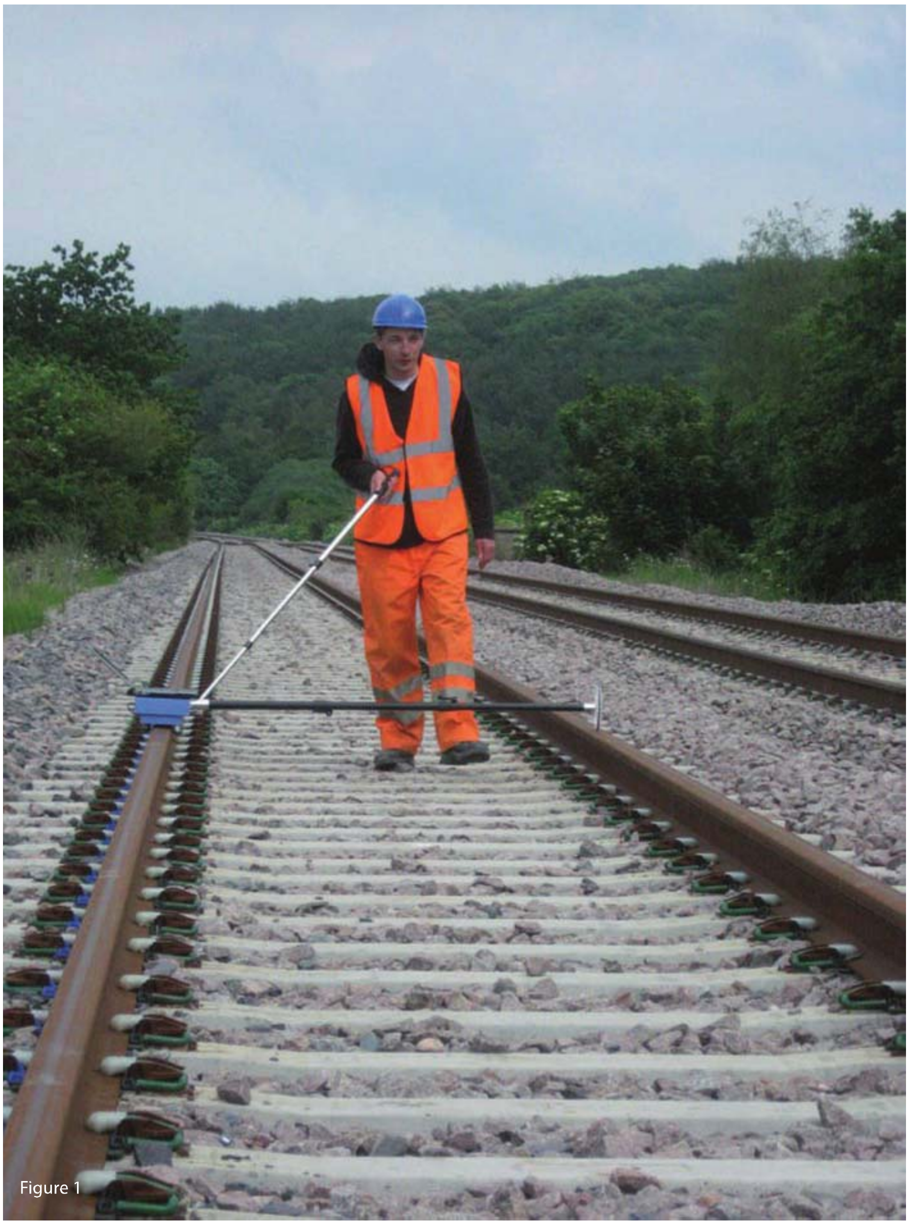


Figure 1

A typical UK situation

Recent measurements at Fishbourne gave us the opportunity to test the suitability of the model for a typical UK situation – before and after a track renewal — using a comprehensive dataset of track and vehicle measurements. This dataset included the roughness of the rail and the wheel, the attenuation of vibration with distance along the track (decay rates) and predictions of the modal response of the wheel, as well as pass-by-noise measurements from the renewed and un-renewed track.

The measurement site was close to Fishbourne station in West Sussex. One of the tracks at the site had been recently renewed while the other remained in its un-renewed state. Both tracks had welded rail on concrete sleepers. An important feature is that when the track was renewed it was fitted with 10 mm natural →

Figure 2

rubber rail pads. These relatively soft pads are now installed as standard on modern track to reduce damage to the sleeper and ballast from impact loading. In contrast, the un-renewed track had thinner and stiffer EVA pads. The rolling stock on the line is predominantly 4-car Class 377 and 3-car Class 313 Electric Multiple Units.

The rail roughness was measured with a corrugation analysis trolley (CAT) trolley [Figure 1]; this is a device that is pushed along the track at walking speed and uses the signal from an accelerometer to derive the unevenness of the track.

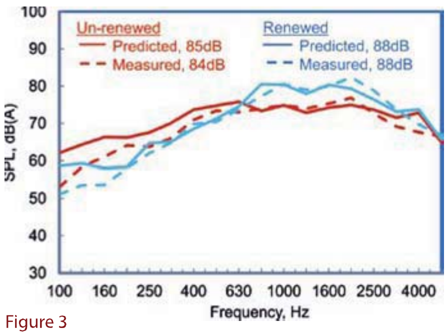


Figure 3

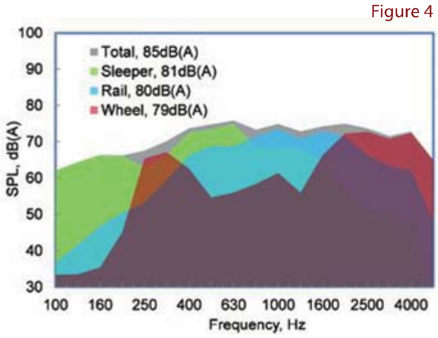
The device is capable of measuring wavelengths between around 3 mm and 0.5 m - at typical train speeds on the line (115 km/h) this corresponds to frequencies between around 64 Hz and 10 kHz. As expected, the renewed track was found to be somewhat smoother than the un-renewed track. The roughness of 64 Class-378 wheels was measured; these wheels are the same wheels used on Class 377's and undergo a similar maintenance schedule. The roughness was measured using a TriTops device– with this a displacement transducer (LVDT) measures the undulations of the wheel surface as it is turned while a tachometer registers the rotation of the wheel. Notably, at all wavelengths the wheel was found to be much smoother than both tracks showing that the influence of the wheel roughness on the overall excitation was minimal.

The length of track excited when a train runs over it depends on the attenuation of the track with distance (decay rate). To measure this requires fixing an accelerometer to the rail head, and making a series of measurements of frequency response to a force impulse at different distances along the rail head [Figure 2].

Renewed track noisier

The decay rate varies with frequency - typically at low frequencies (<400 Hz) decay rates are high, whereas above around 500 Hz waves begin to propagate freely in the rail and the decay rate decreases, before increasing again to a peak at around 5 kHz. When the pad stiffness is high, as is the case for the un-renewed track at Fishbourne, the coupling between the rail and sleeper increases, which increases the sleeper contribution to noise. It also increases the decay rates, reducing the rail component of noise. The result of this is that at most frequencies, the renewed track is noisier than the un-renewed track.

Figure 4



In summary it was found that there were two counteracting effects on the noise due to the track renewal: a reduction in roughness (quieter) and a decrease in decay rates (noisier).

Noise was measured 7.5 m away from both tracks during 37 train passbys over a two day period. These measurements showed that that on average the renewed track was 4 dB noisier than the un-renewed track [Figure 3]. Subsequently, the noise was predicted using the TWINS model, on the basis of the measured roughness levels and decay rates. The wheel was modelled using a finite element model from which the modes shapes and frequencies were extracted. The predictions of noise both in terms of the overall levels and the spectra were found to be in good agreement with the measured values [Figure 3]. It can be seen that the sleepers, rails and wheels all contribute to the overall noise level on the unrenewed track [Figure 4]. After renewal the rail component was much more dominant [Figure 5]. This was due to the reduction in track decay rates which more than offset the small reduction in rail roughness. The component of noise produced by the wheels was about 4 dB less than the track (sleeper plus rail) on the un-renewed track and 7 dB less on the renewed track. Typical of most modern passenger rolling stock in the UK, the wheels of the Class 377 trains are relatively small and the fact they are disc-braked allows the web to be straight - both of these factors reduce the noise radiation.

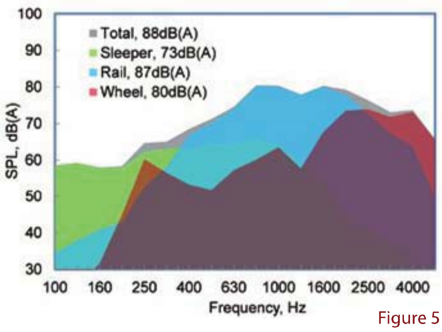


Figure 5

Rail dampers attractive

The results of this study suggest that in many situations typical of the UK, rolling noise is likely to increase somewhat after a track renewal. Furthermore, it is suggested that for modern UK track and rolling stock, the track component of noise will often be of much greater importance than the wheel. This can make technologies such as rail dampers attractive to reduce the noise.●

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