Rail Research UK

The universities' centre for railway systems research

Engineering Interfaces

Track Stability

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Research Partners: Network Rail
Manchester Metropolitan University

Summary

During curving train/track interaction are at their most complex. Centrifugal and wind forces give rise to lateral loads in addition to the normally present vertical loads leading to asymmetric loading of the track as shown in Figure 2. Dynamic loading is also present and is caused by imperfections from the design geometry of the track, imperfections in the wheel profile and variation in load response of the track system.

Recently, tilting trains capable of travelling at up to 140mph were introduced onto the West Coast Main Line (WCML) operating from London to Glasgow. The ability to tilt allows these trains to curve faster than conventional trains and maintain higher mean speeds to cover distances in shorter time. These trains apply extreme modes of loading to the track in comparison to conventional trains.

This research aims to investigate the fundamental mechanisms and factors affecting the resistance at the sleeper/ballast interface under the action of forces applied by high speed tilting trains. In order to investigate the sleeper/ballast interface load resistance available, laboratory experiments have been carried out which attempt to replicate true in-service loading (Figure 2). Also, field measurements of displacements of sleeper deflections during passage of Pendolino trains have been taken and analysed.

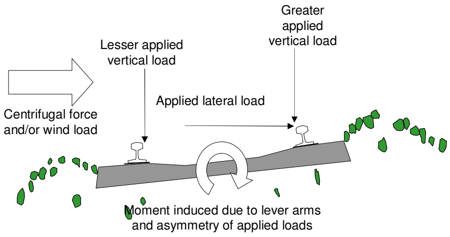

Figure 1 – The track loading under investigation

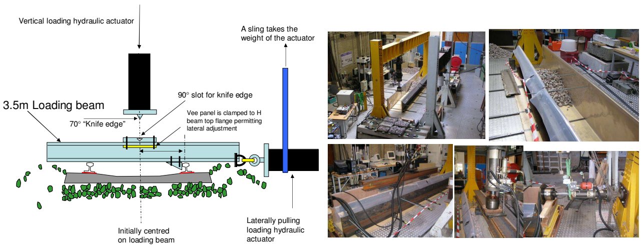

Figure 2 – Laboratory set-up, general arrangement and photos

Some Results

Lab Tests

Geophone data

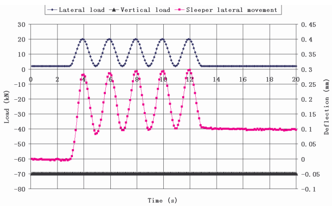

Figure 3 – Graph of load vs. time and deflection vs. time

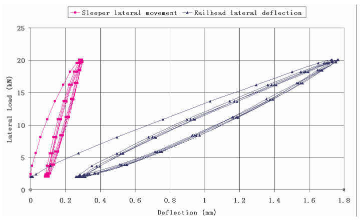

Figure 4 – Graph of lateral load vs. deflection

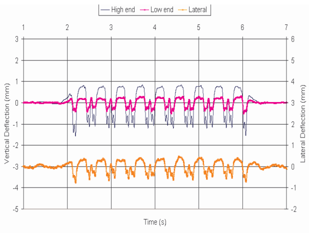

Figure 5 – Geophone data from Pendolino train passage

Discussion:

Figure 3 shows the deflection response of the sleeper when a vertical load of 70kN is maintained and a cyclic sinusoidal lateral force varying between 2 and 20kN is applied. It is interesting to note that after the first load cycle the deflection does not return to the initial position and a slow ratcheting of the displacement can also be seen over the five cycles.

In Figure 4 the displacement with load of both the railhead and the sleeper are plotted for the same loading arrangement as Figure 3. Because the railhead is able to translate and rotate on its fastening to the sleeper it is able to displace laterally more than the sleeper.

In figure 5 geophone data from the WCML is plotted to show the displacement laterally and vertically of a sleeper during the passage of a Pendolino train cornering on an approx. 1000m radius curve at approx. 110mph. The Pendolino consist of 9 carriages, 36 axles and 18 bogey sets. Notice how the inside rail sleeper end deflects less than the outside rail sleeper end due to the moment loading on the track. The lateral deflection is also shown (in orange) and it is possible to identify that the lateral deflection does not recover when axles are close together but ratchets further out only recovering as the mid parts of carriages pass over.

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