Rail Research UK

The universities' centre for railway systems research

Track Stability

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Engineering Interfaces

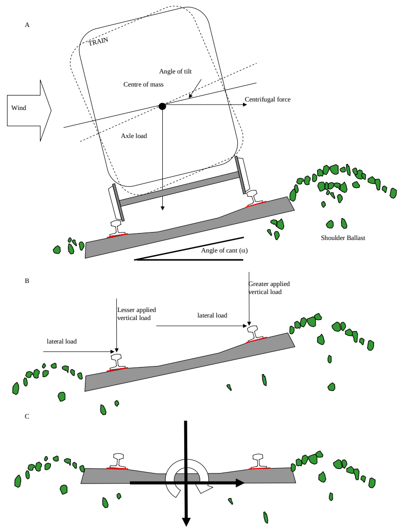

Figure 1 – The track loading under investigation

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. Figure 1 shows how the loads are transferred into the track and can be represented by a combination of vertical horizontal and moment loading applied to the sleeper/ballast interface.

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 behaviour at the sleeper/ballast interface under the action of forces applied by high speed tilting trains. To this end 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.

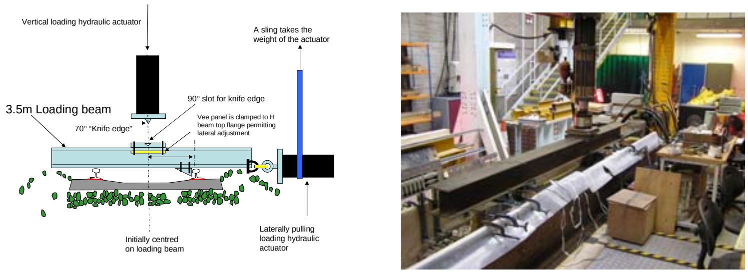

Figure 2 – Laboratory set-up, general arrangement and photo

Some Results

Lab Tests

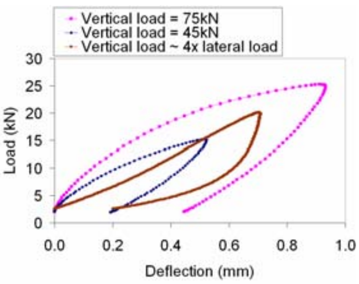

Figure 3 – Results of cyclic lateral load lab tests

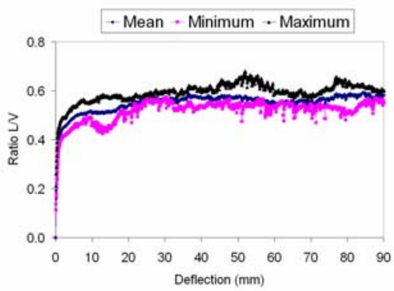

Figure 4 – Results of lateral pull lab tests

Geophone data

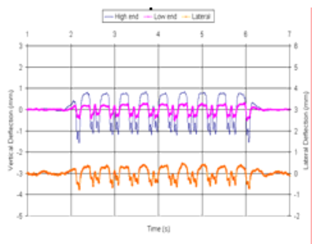

Figure 5 – Geophone data from Pendolino train passage

Discussion

Figure 3 compares the deflection response of the sleeper/ballast interface under different combinations of cyclic lateral and vertical loading. Note that the behaviour is significantly different when the vertical and lateral load are simultaneously cycled compared to tests where the vertical load is held constant.

In Figure 4 results of lateral pull tests are shown. In these tests different vertical loads were maintained and the sleeper pulled at least 90mm laterally. In order to compare tests with different vertical loads the loading ratio (lateral load/vertical load) with displacement of the sleeper is plotted as a mean, maximum and minimum of approx. 20 tests where the vertical load ranged from a minimum of 15kN to a maximum of 75kN. Note that although locally the ratio/deflection line can be highly erratic, there is a clear trend for a consistent L/V ratio for all the tests. The exception to this is at very low deflections (less than 2mm) where the sleeper/ballast behaviour is highly dependent on the vertical and lateral loading

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).

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