Vehicle Dynamics and Track Buckling

There still does not exist an effective technique for detecting locations in track prone to buckling. This makes it imperative that track forces employ preventive and safe M/W practices to avoid track buckling occurrences.

While there has been much research into the mechanism of track buckling, one recent activity examined its relation to vehicle dynamics. The researchers investigated specifically the effects of dynamic vehicle loading on track buckling. They studied results in the vertical plane from the "uplift wave" caused by the vertical car loading, as well as influences in the lateral plane associated with the Lateral to Vertical (L/V) Force Ratio.

Safe temperature increase

Investigators examined the effect of dynamic loading on the *safe buckling temperature increase* for the defined track structure. The concept of "safe buckling temperature increase"[1] states that if the temperature of the rail above a neutral or force-free temperature on tangent track is less than this safe increase value, then buckling will not occur. If it is greater than this value, then the potential for buckling will exist. They found that the presence of the moving vehicle generating a dynamic load can reduce this allowable temperature to below that of the "static value" where the vehicle is absent.

In the vertical load regime, the presence of a moving vehicle generates an uplift wave. This will occur either in front of the vehicle or between two trucks (see Figure 1). The actual magnitude of the track uplift, the associated reduction in the lateral resistance of the track structure, and hence the buckling resistance of the track are related to: truck spacing, axle load, and track stiffness or modulus.

However, for "long" cars, the dynamic buckling temperatures can be reduced by 20 to 30 percent over the corresponding static values.[2] This agrees with test results reported from Eastern Europe. Furthermore, for long train consists — as are common in North America — the

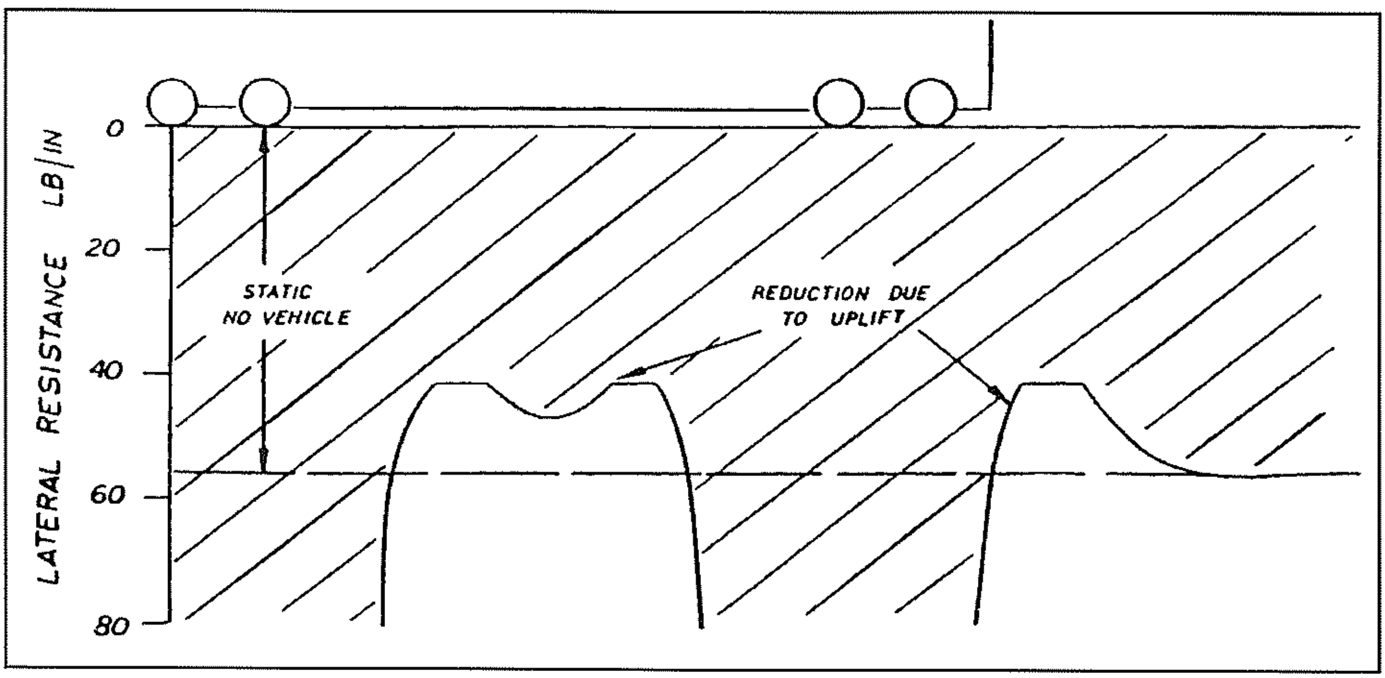

Figure 1 — Lateral resistance distribution under covered hopper car[2]

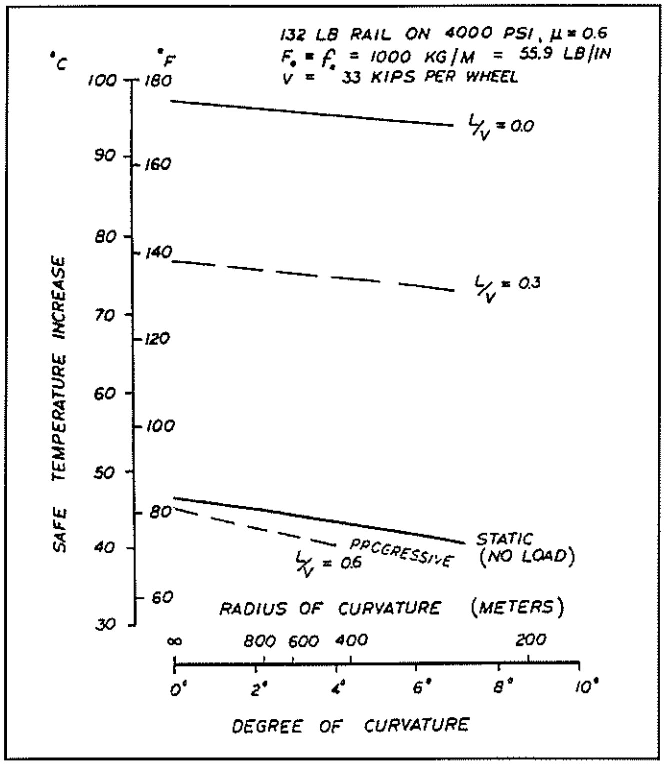

Figure 2 — Effect of truck loads on safe temperature increase for curved tracks[2]

track located between the trucks under each car is more susceptible to buckling than that in the zone ahead of the train. The latter is affected by the single precession wave in front of the lead locomotive.

The influence of curvature

For the case of combined lateral and vertical loads, and associated L/V ratios (both wheel and truck L/V), Figure 2[2] illustrates the relationship between L/V, curvature, and safe temperature increase. It will be noted that for curves of less than 4 degrees, truck L/V ratios greater than 0.6 result in a lower safe temperature increase. Thus, there is a greater potential for buckling than with the corresponding static (non-vehicle) condition.

Where curves are greater than 4 degrees, the mechanism shifts from sudden buckling to a "progressive" buckling. This is of importance where lateral geometric imperfections or defects are present in the track. However, for L/V ratios less than 0.6, the safe temperature increase under the wheel is shown to be less than the static case. This suggests a positive benefit in instances.

In comparing these findings with earlier investigations of track buckling and associated derailments,[3] investigators found that of the 65 derailments attributed to track buckling in one AAR study, 44 (or 68 percent) of bucklings occurred under the train. They noted also that 77 percent of these cases reported normal train operations — that is, without braking. It was thus concluded that "the passage of the train, under normal operating conditions, was a factor in the buckling event."

It should be noted that only 12 percent of the reported track buckling incidents out of a survey of 479 incidents resulted in an actual derailment. No information was available, however, on the time between actual buckling and the passage of the last train.

Still, the passage of a train over a segment of track may disturb the track structure to the extent that it can increase the possibility of a track buckling occurrence. Consequently, buckling derailment behavior, as reported, suggests agreement with the results obtained theoretically on the effects from a moving vehicle in such cases.

References:

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3. Zarembski, A. M.; and Magee, G. M.: "An Investigation of Railroad Maintenance Practices to Prevent Track Buckling"; AREA Bulletin 684, September 1981.