Train Energy's Effect on Track Buckling

Track buckling behavior, its causes and its prevention, have been the subjects of ongoing research for many years. Earlier research (*RT&S,* Feb. 1988, p. 12 and March 1988, p. 12) has addressed the concept of a "safe buckling temperature increase," which attempted to define an allowable temperature increase (above the rail's neutral, or "force-free," temperature) below which the track would be safe from buckling. More recent research has worked to refine this approach by attempting to more accurately define these allowable temperature-increase limits as a function of track conditions and external energy inputs.

One such research program, being carried out by the Department of Transportation's Transportation System Center, has, through a series of theoretical and experimental efforts, attempted to more accurately define these allowable temperature increase limits from a track buckling safety point of view (1). Noting the relationship between temperature increase (above neutral) and lateral movement of the track illustrated in Figure 1, if the temperature increase is greater than the lower limit ($T_L = T_{B,min}$) then the input of an energy disturbance, such as caused by a passing train, can cause the track to move laterally and buckle. The amount of energy required varies as a function of several key track parameters, which include track lateral resistance, curvature, presence of lateral imperfections, or defects, and the temperature increase itself.

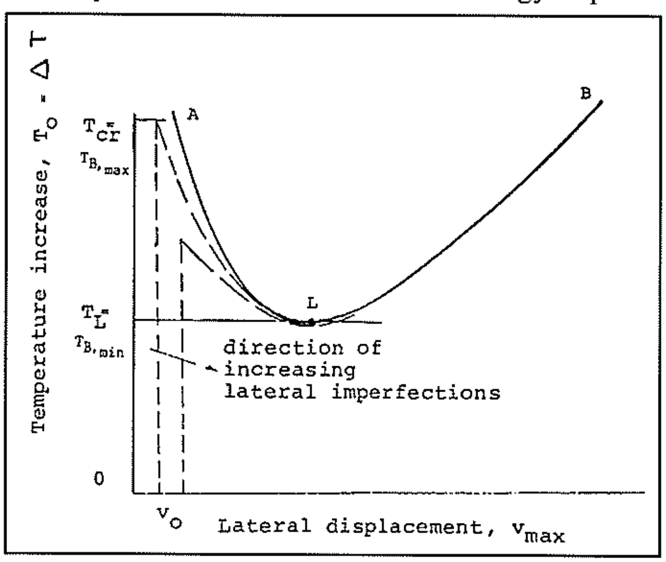

Figure 1 — Theoretical relationship between temperature increase and lateral track movement (2).

Field tests

The relationship between temperature increase and required buckling energy for a five-degree curve with a defined resistance and defect condition is illustrated in Figure 2. In accordance with the theory, the buckling energy decreases as the temperature increase approaches the upper buckling limit ($T_{B,max}$), where it becomes zero. At this upper limit, the track will buckle even without the presence of an additional energy disturbance. At the lower limit ($T_{B,min}$), the required energy input was the greatest. (Below this lower limit, the track will not buckle at all, because the only "equilibrium" configuration for the track is that of the straight track (Figure 1).

This behavior was further confirmed by a series of field tests where the temperature was increased (under a controlled environment) and a test train run over the test track in order to input the external energy disturbance. The results of these tests, one of which is presented in Figure 3, showed good agreement with the theoretical

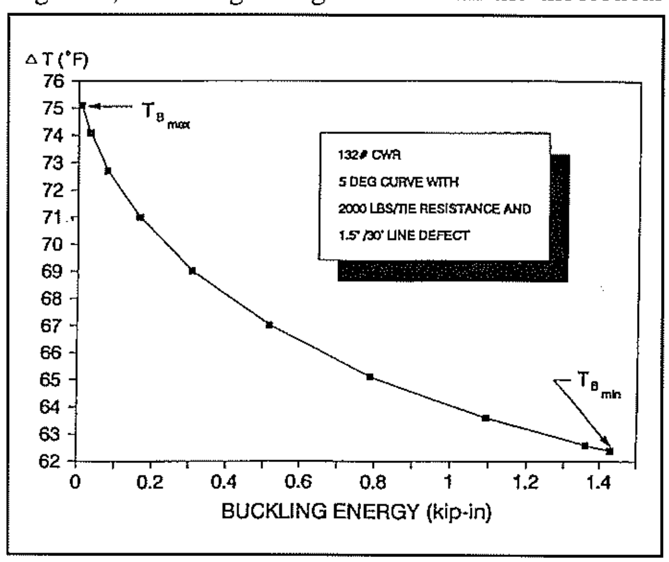

Figure 2 — Energy required to cause buckling in a five-degree curve (1).

behavior, i.e. the track continued to be stable until the temperature level increased above the lower $T_{B,\,min}$. At the point between the lower ($T_{B,\,min}$) and upper ($T_{B,\,max}$) limits, the passing train supplied sufficient energy to buckle the track.

However, the sensitivity of the track structure to buckling is strongly affected by several key track parameters such as lateral resistance, curvature and the presence of lateral defects or imperfections. In order to recognize this sensitivity, and to further note the difference in track buckling behavior that can result from the effect of these parameters, researchers such as those at TSC and in Australia have differentiated track-buckling behavior for tracks with varying levels of buckling resistance. This differentiation is illustrated in Figure 4, where three cases corresponding to track with high-, average- and weak-buckling resistance are defined. In the first two cases, the track behaves in the manner illustrated in Figures 1 and 3, with a range of temperature increases between the upper and lower levels. In these two cases, track buckling often occurs as a sudden buckling or movement of the track. In the third case, the case of track with a low- or weak buckling resistance, however, the upper and lower temperature-increase limits converge to one point, and the track deformation is gradual or progressive.

As researchers refine and improve their theoretical base of knowledge of track buckling, focus is shifting to the determination of the track-strength parameters necessary for the proper determination of the track's resistance to buckling, as well as its actual stress state and corresponding neutral temperature. The more researchers learn about the mechanisms and behaviors associated with track buckling, the better railroad maintenance officers will be able to control and eliminate this mode of track failure.

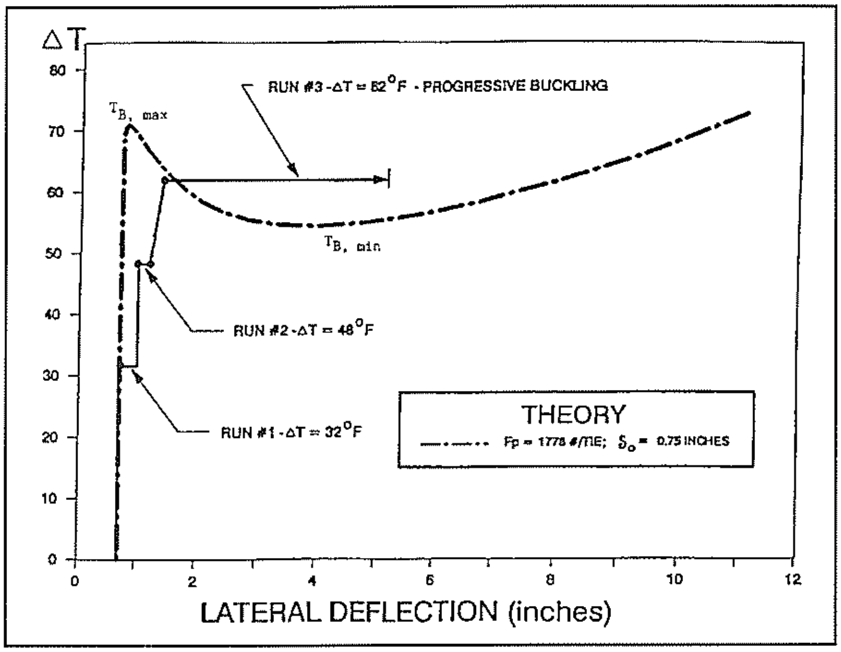

Figure 3 — Comparison of theoretical and test results: Temperature increase versus lateral track movement.[1]

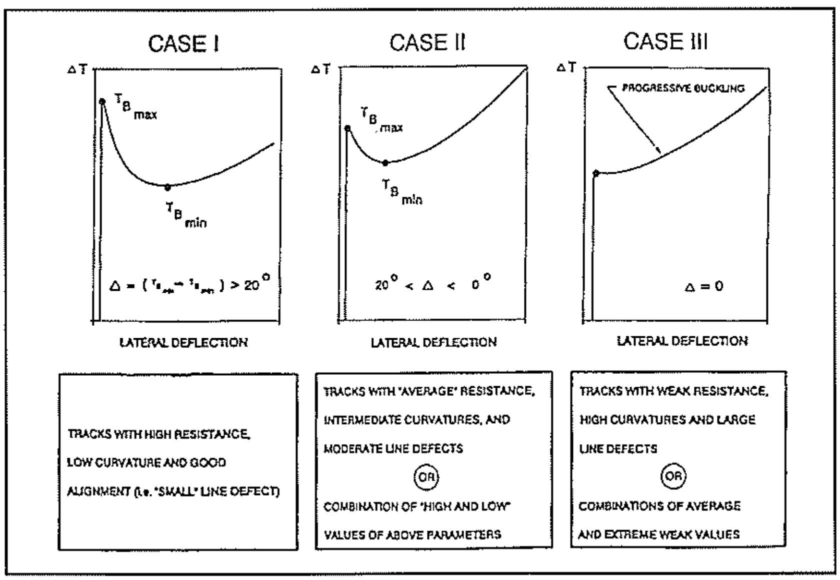

Figure 4 — Effect of track parameters on track buckling behavior (1).

References

(1) Kish, A. and Samavedam, G., "Dynamic Buckling of CWR Tracks: Theory, Tests and Safety Concepts," Transportation Research Board Conference on Lateral Track Stability, St. Louis, May 1990.

(2) Kerr, A. D., "Thermal Buckling of Straight Tracks: Fundamentals, Analyses and Preventive Measures," Bulletin of the American Railway Engineering Association, Bulletin 669, Volume 80, September 1978.

(3) Hagaman, B. R., "The Railways of Australia Track Buckle Projects," Transportation Research Board Conference on Lateral Track Stability, St. Louis, May 1990.