Dynamic Loading of the Track Structure Part I – Vertical Loads

In order to understand the environment that the track structure must withstand, it is necessary to have some knowledge of the loads imposed by vehicular traffic onto that structure. This becomes even more important as new generations of freight equipment are developed and introduced into service. Vehicular imposed loadings are generally divided into three categories corresponding to the plane of loading: vertical, lateral and longitudinal. This article will briefly attempt to define the differing levels of vertical loads imposed on the track structure.

Vertical loading of the track structure consists of the static weight of the freight vehicle and any additional dynamic augments which are superimposed onto this static load. These dynamic augments can be caused by a variety of external factors to include irregularities in the geometry of the track structure, irregularities on the surface of the rail, irregularities on the surface of the wheel, etc. The magnitude of these dynamic augments to the static wheel load is related to the amplitude of the defect, the vehicle operating speed, the unsprung mass of the vehicle and the stiffness of the track, as well as to the vehicle suspension characteristics. Although there have been numerous attempts to analytically characterize this dynamic behavior and its corresponding loadings, direct measurement of the load environment remains an effective technique to define the range of these loadings, as can be expected in conventional railway operating environments.

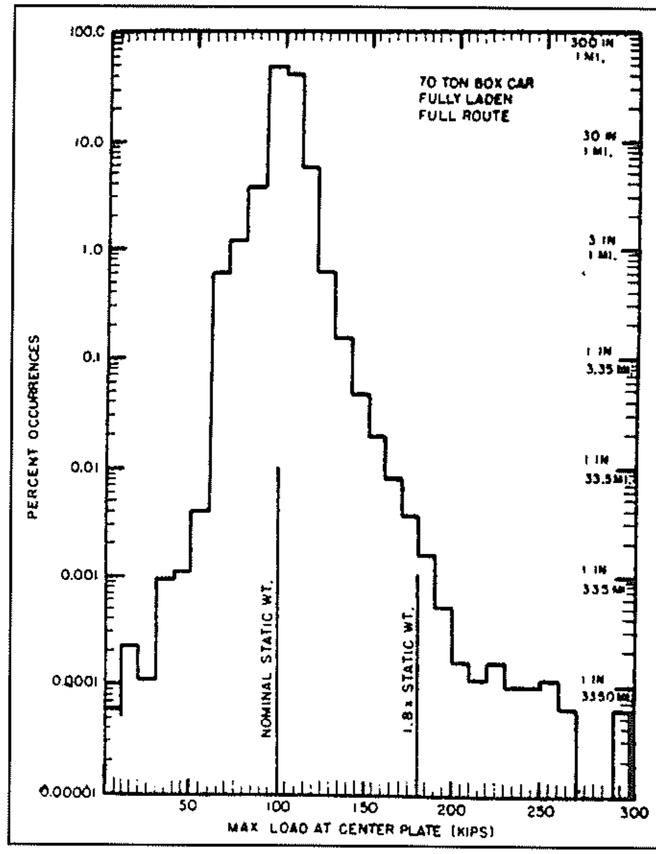

Figure 1 — Center plate loads for 70-ton box car[1]

Recent Research

While measurements of the load environment have been extensively performed over the years, recent research has focused on definition of the loading of the track structure under a broad range of equipment, from 70-ton to 125-ton cars (1). Using techniques developed for wayside (on the ground) load measurements (2,3) and vehicle-borne measurements (4), this recent research has characterized the vehicle/track load environment under a range of conditions and behaviors.

For example, Figure 1 presents the results of over 12,000 miles of vehicle testing on a 70-ton box car. As can be seen in this Figure, the actual distribution of loading is extremely broad, with loads greater than 2½ times static level recorded. At the load level of 1.8 times static, the percent occurrence of this load level was such as to correspond to an occurrence of 2 times every 100 miles (1). Testing of a 100-ton hopper car produced comparable behavior (1).

Conditions of extremely high loadings were found to occur when controlled "bounce" tests over perturbed track (track with defects deliberately installed) were carried out. These results, which are presented in Figure 2 for five different car types, show that peak dynamic loads of between 2 to 4 times the static load were measured under conditions of "bounce resonance" (1). [Note: these vehicles were equipped with conventional suspensions.

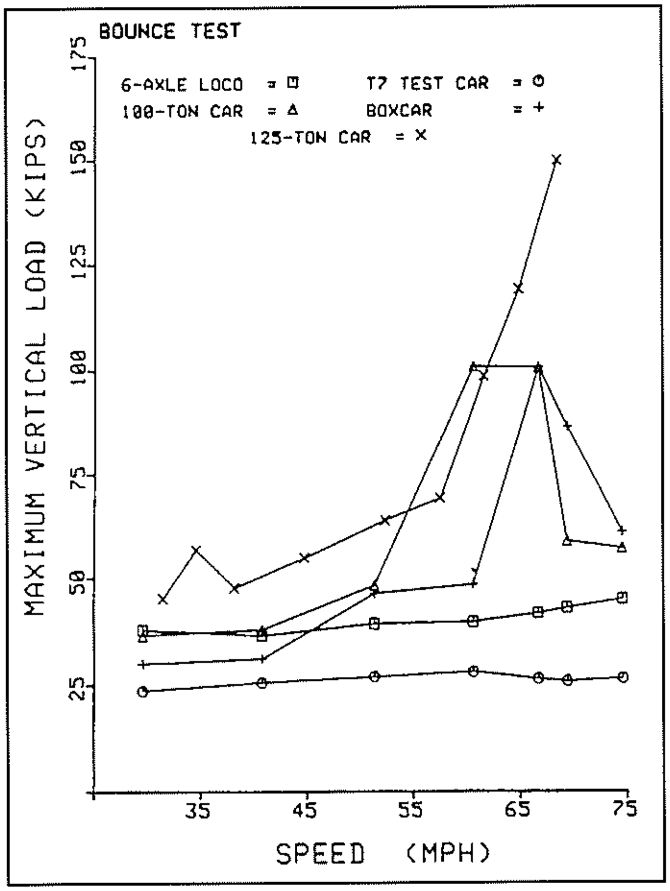

Figure 2 — Vertical loads — bounce test[1]

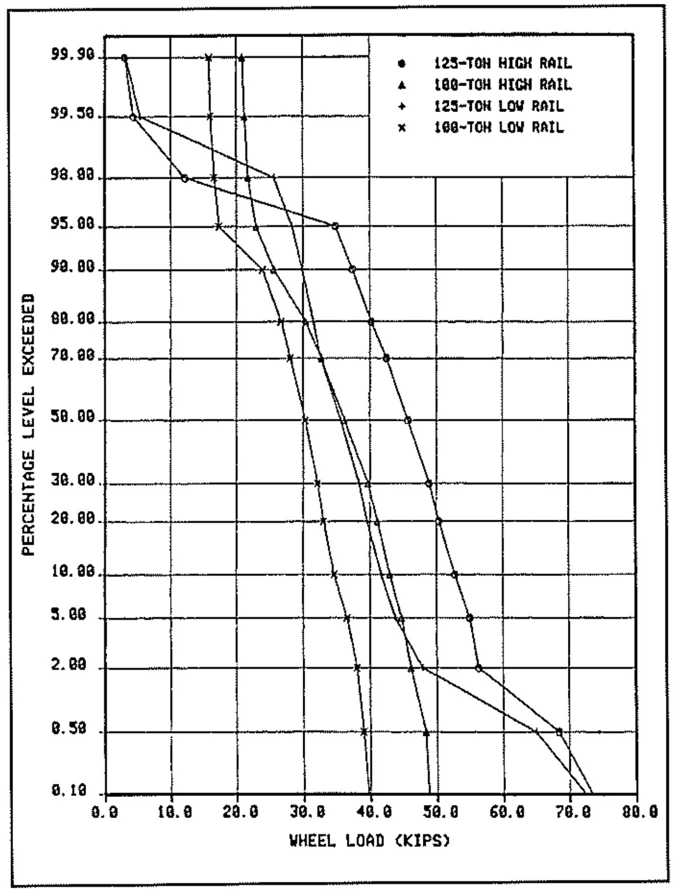

Figure 3 — Probability distribution of peak vertical rail loads at 40 mph, 100- and 125-ton cars[1]

Vehicles with premium suspensions did not produce as high a level of dynamic loading (1).]

Finally, in examining the distribution of vertical wheel/rail loads for operations over controlled track locations [at FAST (1)], the statistical distribution of these loads can be observed (See Figure 3). The median vertical loads, i.e. those loads that were exceeded 50% of the time, were found to be approximately 46,000 lb. for the 125-ton car on the high rail, and approximately 37,000 lb. for the 100-ton car. Comparison of these two car types showed that the 125-ton car produced dynamic loads about 20% higher than the 100-ton car in all levels of exceedance except for the very high levels (1% level or 1 axle in 100 level), where the 125-ton car produced higher dynamic loadings.

While these levels of loading must still be translated into effect on track deterioration, a proper understanding of the loadings imposed on the track structure can serve as a foundation for the definition of the strength requirements of the track and help maintenance officers plan their track maintenance programs under varying types of operating traffic.

References

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(2) Dean, F.E. et al, "A Methodology for Characterization of the Wheel/Rail Load Environment, " Battelle Columbus Laboratories Report to the US DOT Transportation Systems Center, April 1977.

(3) Ahlbeck, D.A., et al, "Measurement of Wheel/Rail Loads on Class 5 Track," US DOT Report FRA/ORD-80/19, February 1980.

(4) Darien, N.J. and Zarembski, A.M. "Railroad Freight Equipment Load Environment Testing," 25th International Instrumentation Symposium, Anaheim, CA, May 1979.