# *Fatigue Life of Steel Bridges*

As the capacity and axle loads of freight equipment continue to increase, the life of the track structure and its components correspondingly decreases. This relationship holds true for track components, such as rail, as has been demonstrated in previous Tracking R&D articles (January 1985 and July 1989), and for railway structures as well, steel bridges in particular.

Steel bridges are subject to a series of repeated dynamic loadings corresponding to the speed and axle loads of the vehicles passing over the bridge. The distribution of the dynamic loading of the bridge structure, corresponding to a large volume of traffic, is a "load spectra" which varies directly with the distribution of traffic over the bridge (1). These loads, in turn, generate stresses (and a corresponding stress distribution or spectra) in the critical members of the bridges such as bridge stringers, floor-beams and hangers. A fatigue analysis of these critical members can be carried out, based on this load (and corresponding stress) spectra and the fatigue properties of the steel material.

### *Dynamic bridge models*

Such fatigue studies have been carried out, using dynamic models of the railway bridge(s) subject to a distribution of trains passing over the bridge at various speeds (2, 3). (Fatigue studies have also been carried out using actual measured stress data in bridges subject to varying traffic distributions (1).) These models allow for the analysis of the effect of varying axle loads and speeds on the bridge structures, and in particular on the fatigue life of the bridge under investigation.

Figure 1 presents the result of one such study in which the fatigue life of the steel bridge members, subject to a given distribution of traffic, have been calculated as a function of the speed of the traffic over that bridge (2). This fatigue life analysis was performed using a reliability-based fatigue methodology, such that the lives presented in Figure 1 were calculated for a 95% level of reliability. As can be seen in this Figure, the life of the members decreases with train speed, since the corresponding dynamic loading increases with speed (See RT&S Sept. 1989, p. 8 and Oct. 1989, p. 11). In addition, note the significant variation in life between the three bridge members shown. (It should be noted that bridges are generally designed with multiple redundancies so that even if one member fails, the bridge can continue to support traffic. This redundancy, however, is specific to the individual bridge design.)

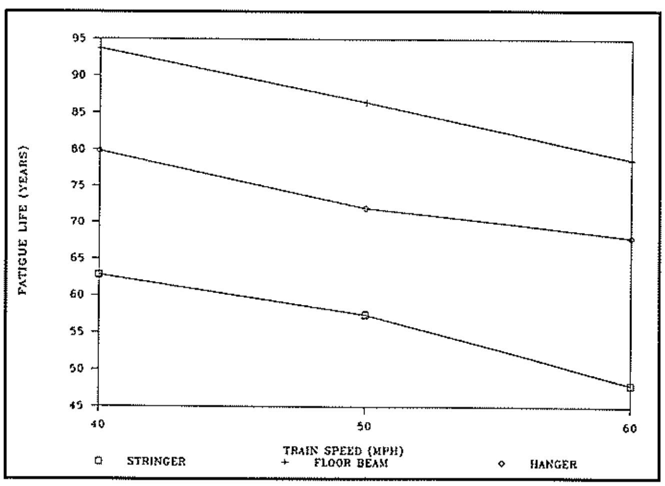


*Figure 1 — Fatigue life of bridge, calculated for 95% reliability (2).*

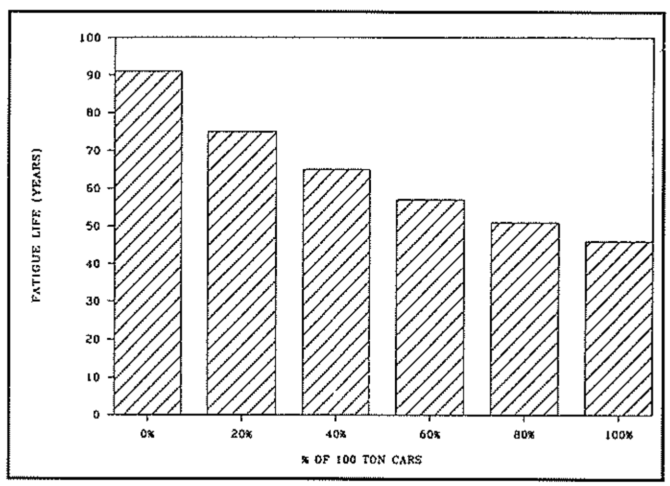


*Figure 2 — Effect of 100-ton cars on fatigue life of bridge hanger (2).*

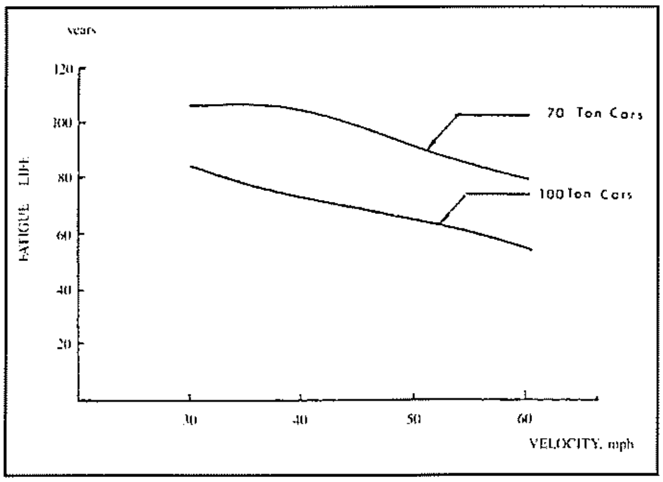


*Figure 3 — Fatigue life of bridge hanger, 70- and 100-ton cars versus velocity (3).*

## *Effects of speed and weight*

The effect of varying traffic loading, in the form of heavy (100-ton) cars is presented in Figure 2. This analysis examined the effect of differing distributions of 100 and 70-ton cars on bridge life (a bridge hanger in this case) at a fixed operating speed (3). As can be seen, increasing the percentage of heavy (100-ton) cars resulted in a direct decrease in the life of the bridge hanger. Figure 3 presents this same type of relationship as a function of train speed, as well as car loading (3). As expected, the life of the bridge hanger under 100-ton traffic is significantly less than that under 70-ton traffic for the full range of train operating speeds .

As traffic loadings continue to increase, the issue of bridge strength and bridge fatigue life will become more important. Thus, even if the static strength of the bridge(s) is sufficient to withstand today's (and tomorrow's) loads, its fatigue life may be dramatically reduced. It is the job of railway engineering departments to continue to monitor not just the static strength of these bridges, but also their fatigue strength and corresponding fatigue lives.

## References


(1) Sweeney, R. A. P., "Some Remarks on the Service Behavior of Steel Railway Bridges," International Association for Bridge and Structural Engineering, Symposium, Zurich, 1979.

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(3) Garg, V K., Chu, K. H. and Wiriyachai, A., "Fatigue Life of Critical Members in a Railway Truss Bridge," Earthquake Engineering and Structural Dynamics, Volume 10, John Wiley & Sons, 1982.