Wood Tie Life: Part II Distribution of Failed Ties

Last month's Tracking R&D looked at the "average" life of wood crossties in track as a function of several key parameters. It noted that wood crossties do not all fail at the same time, even when they are installed together. Rather, small differences between individual ties can result in distinctly different individual tie lives, even when all the ties are subjected to the same loading and climatic conditions.

Differences in individual tie failures can be attributed to the fact that wood is not a homogeneous material. There are differences in species types, as well as variations in the wood properties within a single species. Variations in the amount of preservative absorbed during treatment, differences in local support conditions (and, hence, stress distribution) and other local variations can result in differences in the amount of time it takes a tie to fail.

On an individual basis, these variations in tie condition make it almost impossible to predict the life of a single tie. However, studies of large numbers of ties have shown that the failure of large groups of ties takes the form of a statistical distribution of "failed" ties (1). Figure 1 shows a "normalized" distribution curve for failed ties as a function of a tie's average life (which must be determined independently). As can be seen from this curve, the distribution of tie failures occurs around the "average" tie life (shown at 100% average life) in a less than symmetrical manner. The curve, distributed around the 94% average-tie-life point, indicates that 50% of the ties will have failed after a period corresponding to 94% of the average tie life has passed.

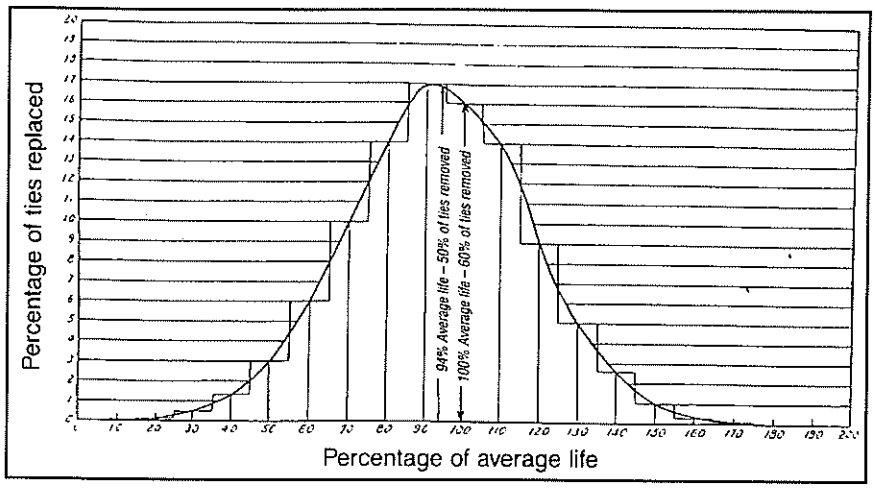

Figure 1 — Frequency curve showing successive percentage of tie replacement for 10 percent intervals of average life[1]

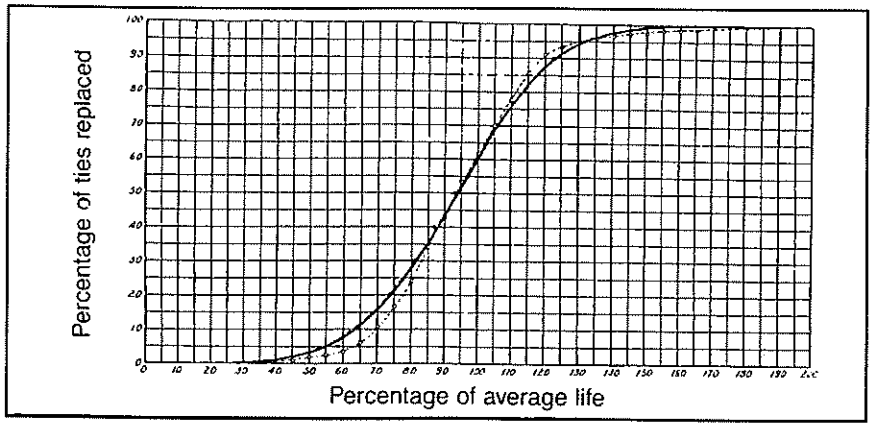

Figure 2 — Curve of total replacements (broken line), 1918 studies; curve of total replacements (solid line), all studies[1]

Figure 2 presents this curve in a slightly different format, with the vertical axis showing the cumulative percentage of replaced ties. (Failed ties are defined as ties that have been replaced by the railway.) This curve allows for the determination of the percentage of ties that will have failed, as a function of their "average" life (1). Although this data was developed based on new or out-of-face tie installations, it can also be used for the analysis of track subject to periodic tie gang cycles (2,3). This information allows for the analysis (and prediction) of the annual rate of tie failures for track that has been

maintained using conventional North American tie maintenance practices.

Recent research

These failure distribution curves have since been validated by more recent railroad data (3,4). An analysis of an all-new construction in which new ties were installed at the same time and subjected to mainline traffic densities of approximately 20 MGT per year is presented in Figure 3. Since the average tie life was not known, the data was plotted against distribution curves calculated for several average tie lives. As can be seen in Figure 3, the actual failure distribution appears to follow the 25-year-average-life distribution curve quite well.

Noting these results, it appears that the distribution of failing ties can be predicted by using such a combination of statistical tie failure distribution curves and an externally obtained (either calculated or estimated) average tie life.

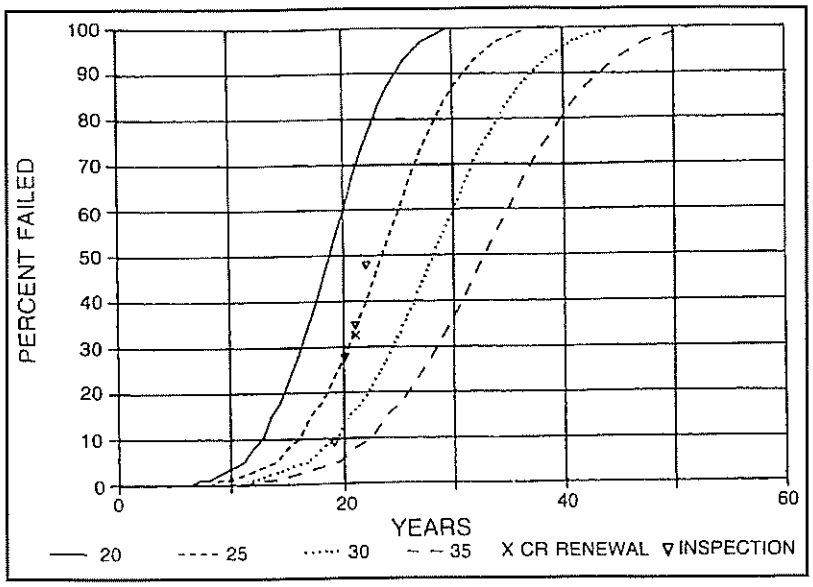

Figure 3 — Forest products curve for various average life values: Cumulative failures versus years in track at mile 266[4]

References

(1) MacLean, J. D., "Percentage Renewals and Average Life of Railway Ties," U.S. Department of Agriculture, Forest Products Laboratory, Madison, Wis., November 1957. Reviewed and Reaffirmed 1965 .

(2) Abbott, R. A., "Track Structure and Methods for Predicting Tie Life," *Crossties*, January 1982.

(3) Wells, T. R., "Tie Failure Rate Analysis and Prediction Techniques," Association of American Railroads Report R-515, October 1982.

(4) Davis, D. D. and Chow. P., "Tie Condition Inspection: A Case Study of the Failure Rate, Modes, and Clustering, "Bulletin of the American Railway Engineering Association, Bulletin 723, Volume 90, December 1989.