Examining Wood Tie Failure

Though conventional wood tie systems have been in use since 1831[1], research into tie failure is still an ongoing process.

The factors that affect the rates of wood tie failure encompass mechanisms such as mechanical and biological degradation, and weathering. Table 1[1] lists some of these mechanisms — factors that in turn combine to cause the deterioration resulting in the removal and replacement of the ties. The relative percentage of failure from each of the mechanisms noted can vary with traffic density and location.

One AREA study[2] indicated that, in general, 43 to 44 percent of ties are removed because of a combination of decay and deterioration leading to crushing in the tie plate area. An additional 18 to 20 percent are removed for having been plate cut, 16 to 18 percent from splitting, and 14 to 16 percent from spike killing. The remaining are removed for a broad range of additional reasons. However, mechanical failure related in turn to the stress and use factors, as defined in Table 1, tend to dominate the failure mechanisms—particularly in hardwood ties.[1]

I. Weathering Factors:
   A. Temperature (elevated, cyclic = depressed).
   B. Water.
   C. Temperature-moisture interactions (i.e. freeze-thaw).
II. Biological Factors (primarily fungi).
III. Stress Factors:
   A. Abrasion and compression due to ballast.
   B. Impact compression due to vertical rail loads
   C. Impact bending due to vertical rail loads.
   D. Spike loading due to lateral rail loads.
IV. Incompatibility Factors:
   A. Chemical degradation due to presence of rusting metal and high concentrations of acidic salts.
   B. Physical degradation due to particulate matter under tie plate during loading.
V. Use Factors:
   A. Quality and frequency of maintenance (i.e. spike removal, adzing, type of ballast).
   B. Track geometry (i.e. curves, ties per mile).
   C. Accidents (derailment, dragging equipment, spills).

Table 1 — Degradation factors affecting service life of crossties.

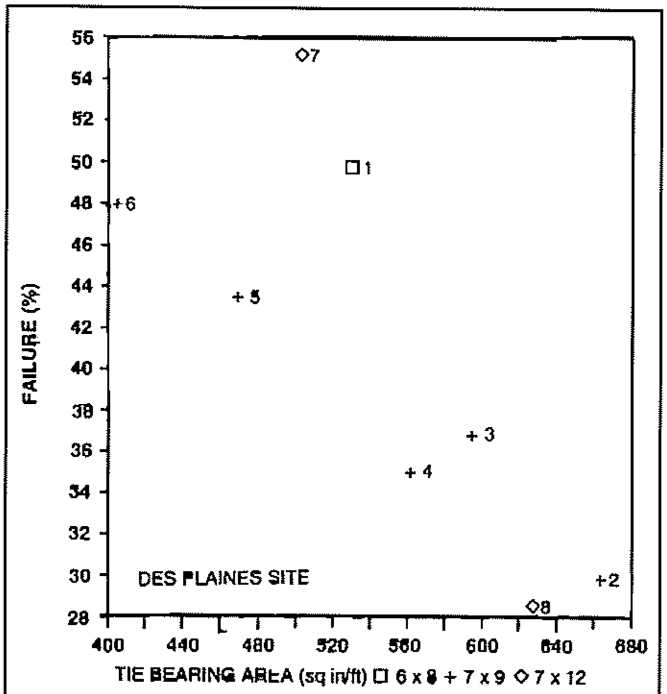

Figure 1 — Failure rate vs. tie bearing area

Long-term testing difficult

Because of the relatively long life of hardwood crossties, from 20 to 30 years for average mainline life,[1] it is difficult to maintain a significant tie testing program to failure. One test, however, has been taking place since 1967.[3] The test site is on the Chicago & North Western Railroad near Des Plaines, Illinois. The test was set up to evaluate the effect on tie life of key tie design factors, namely: tie length, varying from 8 feet to 10 feet, tie cross section from 6 inches by 8 inches to 7 inches by 12 inches, and tie spacing from 19½ inches to 29¼ inches. This test track currently experiences about 30 MGT of traffic annually. It was evaluated recently for tie failure, and the percentage of failed ties have been examined in relation to the dimensional parameters noted previously.[3] There were several interesting observations:

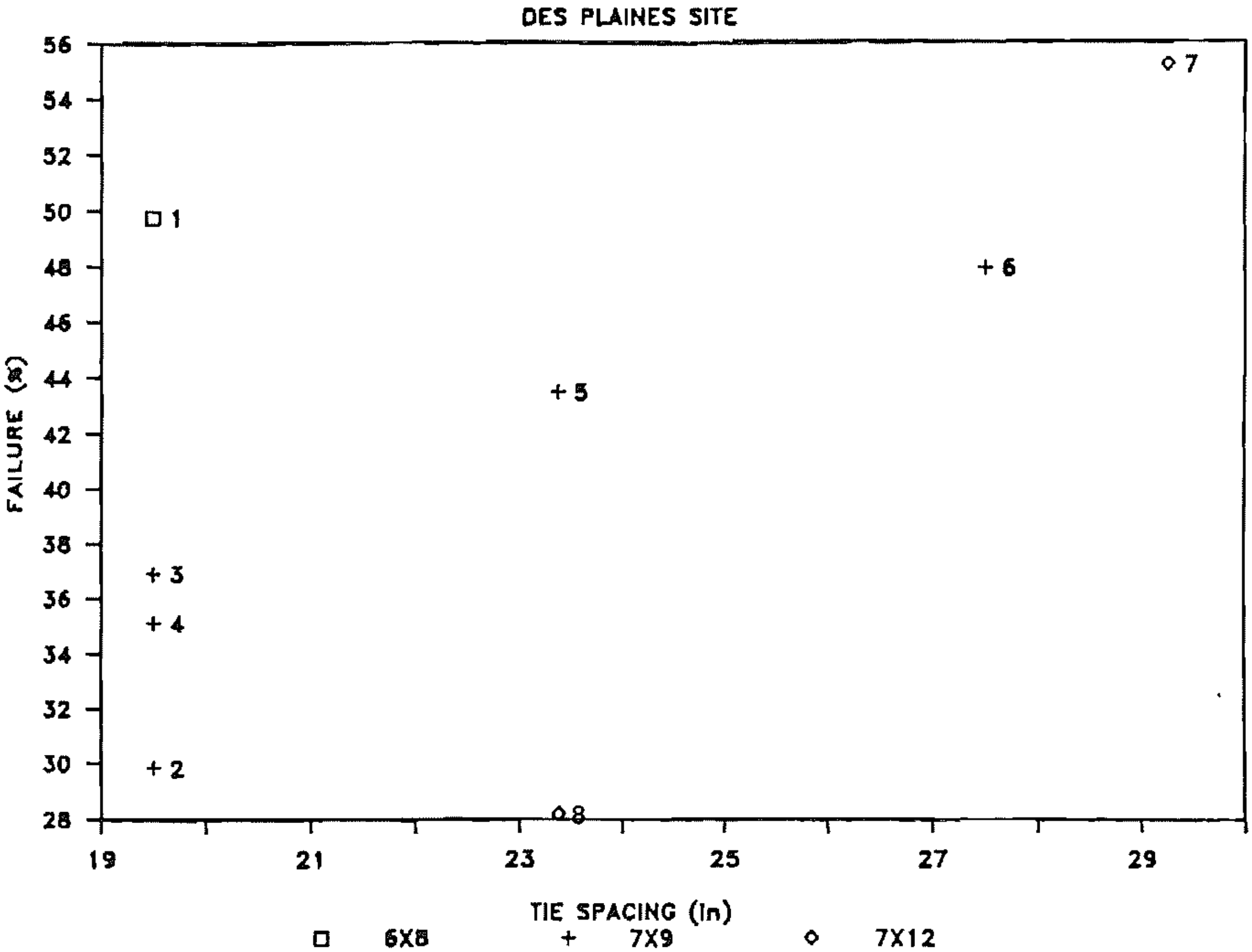

Figure 2 — Failure rate vs. tie spacing

Dowel-lam okay, too!

Overall, it was found that the best performing ties tended to be those with "standard" 7-inch by 9-inch cross sections and 19½-inch spacing, as well as a section of track with dowel-laminated 7-inch by 12-inch ties at 23⅜-inch spacing. As for the effect of tie length on failure rate along the test section, no significant difference was found between the 8½-foot and 9-foot ties. There was, however, some better performance from the 10-foot ties.

Examination of the influence of tie cross section revealed a distinct improvement in performance with increasing cross section. Thus, the 7-inch by 9-inch ties performed better than the 6-inch by 8-inch, while the 7-inch by 12-inch served better than both.

Increasing tie width and length enlarges, in turn, the bearing area of the tie. Figure 1 shows that the rate of tie failure decreases in direct relation to the increase in the bearing area.

Finally, with examination of the effect of tie spacing, there was found a direct correlation between increased spacing and an increased percentage of failed ties. This trend held for 7-inch by 9-inch and 7-inch by 12-inch cross sections, and is illustrated by Figure 2.

No variation between fact and theory has arisen from the information gleaned thus far from the Des Plaines site. Namely, that under mainline conditions, where mechanical degradation modes dominate tie life, those parameters which serve to reduce the level of stress on the tie serve also to improve its performance. However, it must be noted that other factors, such as the relative cost of the larger ties or closer tie spacing have not been addressed in the study noted. As a consequence, it still remains for the railroad maintenance officer to relate this type of information to the specific conditions of traffic and cost on his or her railroad.

References:

1. Chow, P., Lewis, S. L., and Reinschmidt, A. J.: "Effects of Natural and Accelerated Aging on Oak Crossties"; Proceeding, American Wood Preserves Association, 1987.
2. American Railway Engineering Association: Report of Committee 3, Tie and Wood Preservation; Bulletin 661, Jan. 1977.
3. Davis, D. D., and Shafarenko, V.: "Tie Condition at Des Plaines; A Progress Report"; Bulletin of the American Railway Engineering Association, Bulletin 713, Dec. 1987.