U.S. Department of Transportation
Federal Railroad Administration

Dynamic Wheel Load Detector Extends Life of Concrete Railroad Ties

Problem

In 1978, Amtrak began a major installation of concrete ties on the Northeast Corridor (NEC) as part of a massive rehabilitation and improvement project. Until that time, concrete ties had been considered new technology by U.S. railroads even though they had been used widely abroad. As part of its charge to undertake performance research and development on new products, the Office of Research and Development, Federal Railroad Administration (FRA), began a study early in 1980 to compare the performance of concrete ties at the Facility for Accelerated Service Testing (FAST) in Pueblo, Colorado, with the performance of those in operating railroad service. The purpose of the study was to determine whether concrete ties could be used effectively by U.S. railroads, a subject of debate at that time.

In June 1980, the first inspection of the concrete ties that had been in use in NEC for about 18 months produced results that were surprising. Many of the ties already exhibited rail seat cracks, which from past experience were known to lead to premature tie failure. Subsequent inspections and investigation established that these cracks were being caused by the dynamic wheel/rail loads produced as a result of wheel-tread irregularities on passenger coaches and freight cars traversing the corridor. A load of more than 75,000 lb was considered to be large enough to initiate concrete tie cracks. Repeated occurrences of loads of more than 75,000 lb caused growth in the cracks. It was found that a low number of such events could cause excessive damage to a tie. (Total failure of a concrete tie occurs when the end of the tie separates through shear failure. The resulting loosening of the rail fastener leads to a loss of rail gauge.)

No cracks were experienced on the concrete ties at FAST, where no wheel tread irregularities exist on the test train. A close visual inspection of the wheel treads on several Amtrak passenger coaches revealed that tread irregularities were 18 to 20 inches long and difficult to detect visually.

Suggestions for "Research Pays Off" article are welcome. Contact Nancy A. Ackerman, Editor, TR News, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone: 202-334-2972).

Solution

Two research projects were undertaken, one under FRA sponsorship and the second under joint Amtrak and FRA sponsorship, to alleviate the large dynamic loads causing the concrete tie cracks. The first effort resulted in the use of a more resilient tie pad between the rail and tie. The new tie pad acted as a mechanical filter reducing the high-frequency (300 to 700 Hz) loads' being transmitted into the tie and resulting in tie resonances. Because the tie pads alone were not sufficient to attenuate the largest loads, a device was needed to facilitate detection of excessive loads. The Battelle Columbus Laboratories in Columbus, Ohio, was hired for the second effort to design and build a wheel impact load detector (WILD).

The development of high-speed microprocessors made the WILD possible. The primary function of the WILD is to collect peak-load data for all wheel sets passing the installation and report these data to a remote printer. The data are used to determine the wheel truing (reprofiling) requirements for specific wheels that have passed the detector. Recent improvements in the software provide for reporting not only which axle on which car is responsible for the large dynamic load, but also whether it is a passenger or freight car and the type of car.

Application

The first WILD was installed on Amtrak's Northeast Corridor track near

Edgewood, Maryland, in 1983 (see Figure 1). The system used four circuits on a single rail. After system checkout and troubleshooting were completed, collection of data began in late 1983.

In January 1984, all wheels on Amtrak passenger cars that were generating track impact loads greater than 60,000 lb were scheduled for wheel truing. The 60,000-lb threshold was chosen to give Amtrak a sufficient margin of error below the 75,000-lb cracking thresholds. The result was an immediate decrease in the number of wheels producing loads greater than 60,000 lb. A plot of the results obtained as a running 4-week moving average of extreme value statistics is shown in Figure 2. Within a 2-month period, the number of events exceeding the 60,000-lb level decreased to below 0.05 percent. No similar wheel truing program existed for freight cars on the corridor; therefore the level of high-impact events for freight loads greater than the 60,000-lb level remained about the same.

The success of this research program led to the installation of three impact detectors on the Florida East Coast Railway, and one each on the British Rail System, Conrail, and the Canadian National Railroad. Amtrak also installed two new, upgraded versions of the WILD near the original installation. The original installation has since been removed. WILD research spawned a new high-tech company in the Columbus, Ohio, area that makes and installs the WILD system.

Benefits

The NEC load detector was installed to protect the $37 million investment in concrete ties. Through the use of the WILD, as well as resilient tie pads, failure of concrete ties on the NEC was prevented. All the ties with seat cracks that were detected in June 1980 are still in place and growth in the cracks has been halted. There is no quantitative estimate of the number of ties that would have failed if the WILD had not been installed. However, until the WILD was installed on the NEC, all major concrete tie installations in the United States had experienced this type of failure. The cost—benefit analysis used to justify the use of concrete ties assumed a life expectancy of 50 years. If previous experience is an accurate barometer of the premature failure due to rail seat cracks, this life expectancy would have been reduced to 15 to 20 years.

Two beneficial side effects have resulted from the use of the WILD. One is that Amtrak has reported a sharp decline in axle bearing problems since the WILD was installed—from one event per month to one event every 6 months. This has considerably reduced the risk of an accident due to bearing failure. The other beneficial side effect is a reduction in energy costs. A typical wheel-tread irregularity dissipates about 20 horsepower per wheel into the track and vehicle. For a loaded 100-ton car on a concrete tie track this translates into an additional 100 lb of train resistance. Although no quantitative analysis of the energy savings has been done to date, a rough estimate is that an approximately 0.5 percent reduction in energy would result.

The important long-term benefit of the WILD to railroads is its contribution to increased productivity. Cost-cutting methods already being used by the railroads are reductions in work force and increased mechanization of track work. Detecting devices, such as the WILD, provide means for obtaining the maximum useful life of track components in times of reduced maintenance work forces. The long-term savings to the railroads will be substantial.

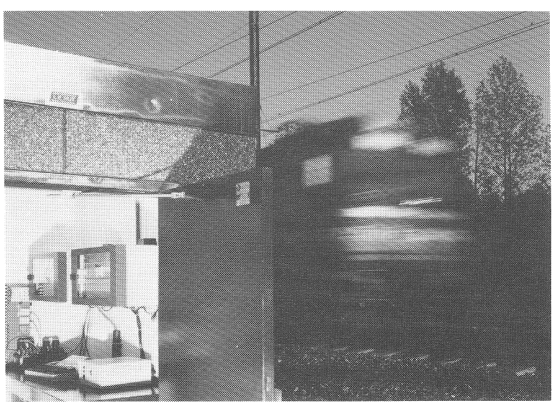

FIGURE 1 WILD installation on Amtrak's Northeast Corridor track near Edgewood, Maryland.

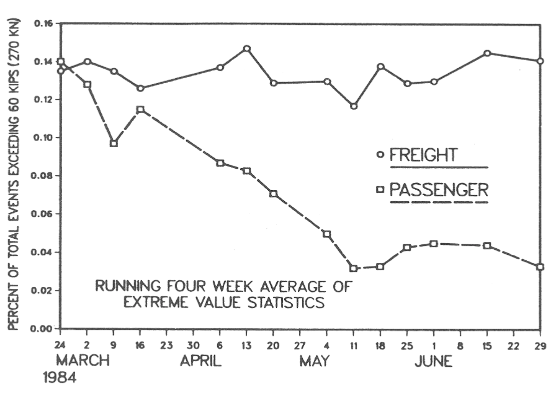

FIGURE 2 Amtrak wheel improvement program results compared with reference weight traffic.

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