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Brake Beam Fatigue Environment for Truck Mounted Brakes

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Summary

The Transportation Technology Center, Inc. recently conducted a brake beam test on a car equipped with truck mounted brakes for comparison to a similar test conducted on a car equipped with body mounted brakes (TD06-030).

Tests conducted in 2005 on body mounted brakes showed that the stresses in brake beams were the highest near the brake head. This is consistent with most of the failures observed in service, although there are some failures that occur at the center of the brake beam. It was thought that the stresses at the center of the beam might be more pronounced with truck mounted brakes.

Tests repeated in 2006 using truck mounted brakes showed the following:

- The relative influence of wheel condition and brake application on brake beam stress for truck mounted brakes was similar to that measured in 2005 for body mounted brakes.
  - Stress was magnified on the brake beams when the brakes were applied.
  - High impact wheels are a major contributor to brake beam damage.
- The truck mounted braking system did not have a significant effect on the location of peak stresses on the brake beam compared to body mounted brakes. The peak stresses were measured on the tension member near the brake head in both tests.
- The magnitude of the stresses was lower on the beams used with truck mounted brakes. The tension member was 1 1/2 inches in diameter for the truck mounted brakes compared to 1 3/8 inches for the body mounted brakes.

A goal of the research is to quantify the load environment required for creating a specification for testing brake beams and a standard for their fatigue performance. Future work will focus on fatigue analysis and life.

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BACKGROUND

The objective of recent research has been to identify and validate inputs that could be used in developing a fatigue test to evaluate a given design's resistance to fatigue failures.

Tests were performed in 2005 to measure the fatigue environment of brake beams.* A pair of brake beams was instrumented with strain gages and accelerometers and installed in an aluminum coal car equipped with body mounted brakes and tested in revenue service. Tests were repeated at the Transportation Technology Center (TTC) with the same wheelsets that were used in revenue service as well as a pair of out of round wheelsets and a pair of wheelsets with built up tread. Results showed:

- Stress was magnified on the brake beams when the brakes were applied.
- High impact wheels are a major contributor to brake beam damage.

The highest stresses measured in the 2005 tests were on the tension member near the brake head. This is consistent with the majority of brake beam failures.

In 2006, Transportation Technology Center, Inc. (TTCI) conducted another brake beam test at TTC. TTCI instrumented and tested a pair of brake beams on a car equipped with truck mounted brakes. The goal was to determine whether the different loading configuration of truck mounted brakes would cause higher stresses, stresses in a different location, or some other behavior that would require a special fatigue test for brake beams used with truck mounted brakes.

METHODOLOGY

The brake beams from an aluminum gondola car equipped with truck mounted brakes were chosen for testing. The beams were instrumented with strain gages and accelerometers. The strain gages were mounted in the same positions as on the brake beams used in the 2005 tests. The exception to this was that the strain near the pinhole of the strut was not measured. Instead, the beam on which the brake cylinder was mounted was instrumented with strain gages on the center of the compression member, where the strut connects. Gages were placed at the edge of each side of the angle. Figures 1 and 2 are photographs of the strain gage layout. Vertical accelerometers were mounted near the brake head. Both the brake beams in the lead truck were instrumented.

The test was performed with an empty car. Three pairs of wheels were used in the test truck.

- Good wheels (no tread damage)
- Out of round wheels
- Built up tread wheels

Each pair of wheels was tested at 30, 40, and 50 mph on the Transit Test Track at TTC. Brake applications were made at minimum service, 13-pound reduction, and a full-service brake application.

Figure 1. Strain Gages on the Tension Member of the Brake Beam

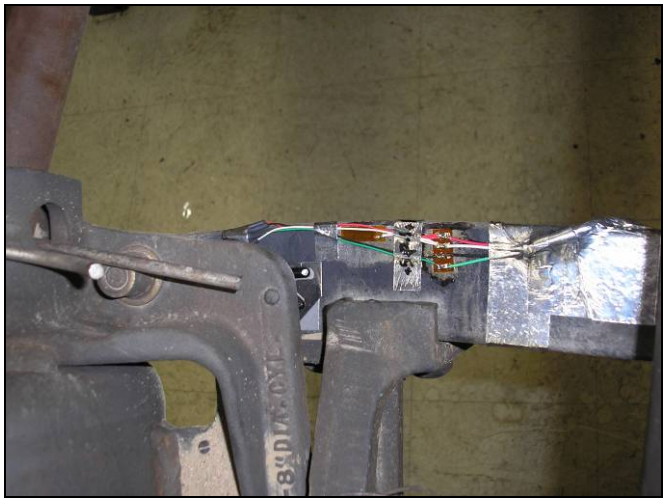

Figure 2. Strain Gage on the Compression Member of the Brake Beam

RESULTS

Data collected with truck mounted brakes was reduced in the same manner as that for the body mounted brakes. Data was cycle counted and the range of values was plotted against the number of counts. Data was segregated by the wheelsets used and by brake application. Figure 3 shows a comparison of the cycle counted data for tests with truck mounted brakes and with body mounted brakes. This plot contains data for heavy brake applications. These measurements were on the tension member near the brake head. The peak stresses for the truck mounted brakes are much lower than those measured with body mounted brakes. This was consistent for all the channels.

* see TD06-030, December 2006

The reduction in stress on the truck mounted brakes compared to the car mounted brakes may be explained by the beam design. The beams used on the car mounted brakes were AAR-18 beams with a tension member approximately 1 3/8 inches in diameter. The beams used on the truck mounted brakes had a tension member approximately 1 1/2 inches in diameter.

Figure 4 shows cycle counted data for the truck mounted brake test. Data is for the strains on the tension member of the beam near the brake head. The braking and wheel conditions are separated to show the influence of each one. The data shows trends similar to the previous test, with high impact wheels showing much higher stresses than baseline wheels. It is also apparent that applied brakes couple the brake beam to the input from the track, producing higher stresses.

Data for several strain locations on the same beam is plotted together in Figure 5 for truck mounted brakes and in Figure 6 for body mounted brakes. The data in these figures is for built up tread wheels, and all brake application conditions. The plots show that the highest stresses measured are on the tension member near the brake head. This is consistent with the location for most brake beam failures.

It was expected that the beams used with truck mounted brakes would have higher stresses in the center of the brake beam, but the data does not show this. The peak stresses on the beams with body mounted brakes are about 22.5 ksi near the brake head and about 15 ksi in the center. The peak stresses on the beams with truck mounted brakes are about 17 ksi near the brake head and about 9-10 ksi in the center. The absolute difference is about the same in both cases, but proportionately the difference is actually larger for truck mounted brakes.

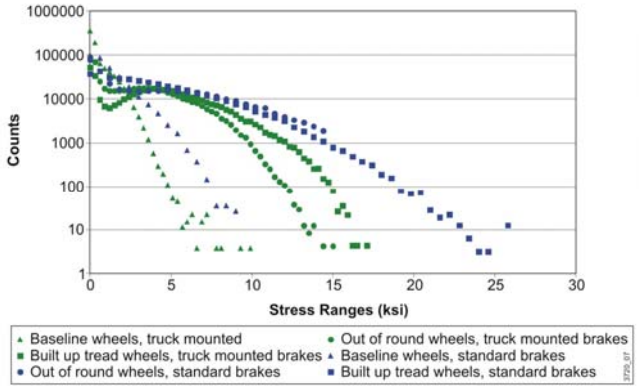

Figure 3. Cycle Counts for Test Periods with Heavy Brake Application

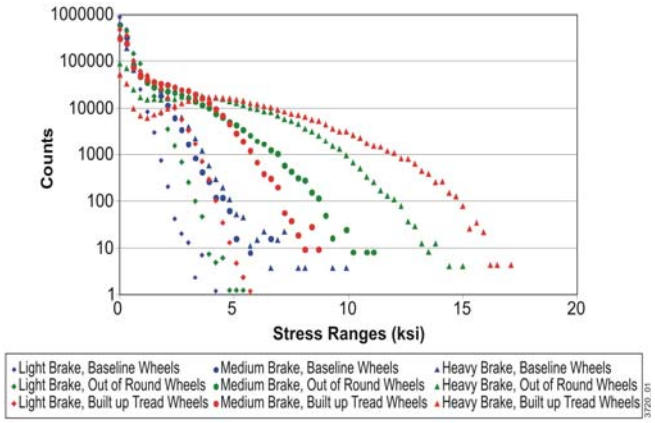

Figure 4. Cycle Counts for Tension Member on Lead Brake Beam, left side (near the brake head, truck mounted brakes)

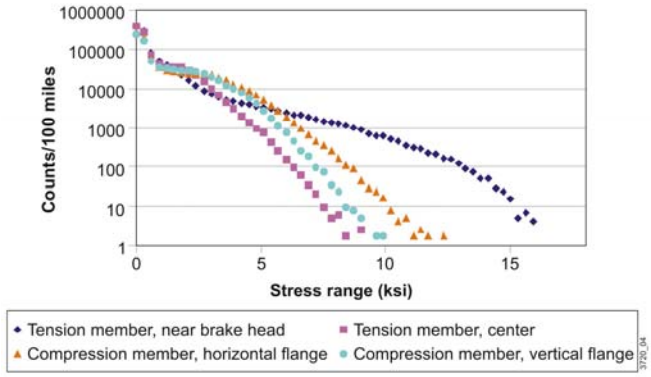

Figure 5. Cycle Counts for Four Locations on the Brake Beam Truck Mounted Brakes

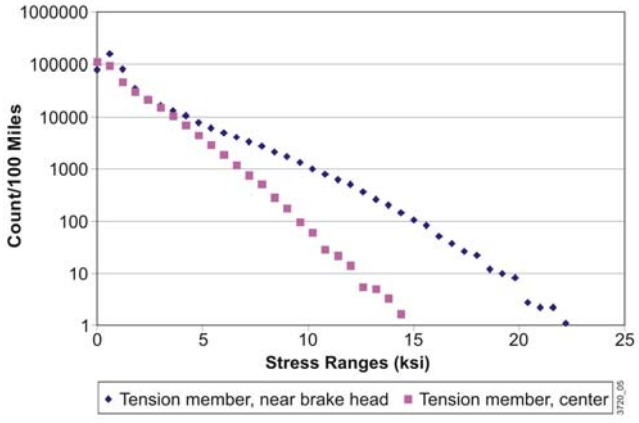

Figure 6. Cycle Counts for Two Locations on the Brake Beam Body Mounted Brakes

CONCLUSIONS

Although it was expected that the truck mounted brakes might produce high stresses in the center of the beam, the highest stresses were found on the tension member adjacent to the brake head — just as they were with body mounted brakes.

The stresses measured with the truck mounted brakes were lower than those measured with body mounted brakes. This is at least partly because the brake beams used with the truck mounted brakes were somewhat heavier than the brake beams used with the body mounted brakes.

The effect of brake application and wheel condition on brake beam stress was confirmed to be similar for both truck mounted or car mounted brakes.

Wheel surface conditions and resulting impact forces are believed to be the major contributors of brake beam fatigue and failure.

FUTURE WORK

The stresses measured in these tests should be compared to those produced in the Association of American Railroad's (AAR) dynamic test and/or a proposed fatigue test specification (*Manual of Standards and Recommended Practices*, Section D, Brake Beam Specifications and Tests, AAR Standard S-344.) This would involve the following steps:

- Estimate the portion of time the brake beam experiences high impact wheel conditions and low, moderate, and heavy brake applications. Determine the effect of these variables on fatigue life.
- Confirm that passing a proposed fatigue test would indicate acceptable brake beam life. This might involve testing some beams to demonstrate that the applied loads are producing the appropriate strains.
- Determine the acceptable fatigue life of a brake beam.
- Calculate the fatigue life based on the actual revenue service test data.