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Short Heavy Axle Load Cars: Bridge Test at FAST

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Summary

Transportation Technology Center, Inc. (TTCI) is investigating the effects of heavy axle load (HAL) traffic on infrastructure, specifically as related to minimum length (approximately 42 feet) interchange cars. Testing at the Facility for Accelerated Service Testing (FAST) conducted to determine differences in bridge response due to two car types found that short cars do not cause larger maximum stresses on the relatively short spans at FAST. Four steel spans — measuring 24' 4", 31' 10", 55' 5", and 64' 8" — were instrumented with strain gages and string potentiometers and tested under train operations with two different car lengths. Further observations are as follows:

- As predicted, the 64' 8" span has slightly higher stresses due to short cars when compared to the standard 53-foot cars.
- Also as predicted, the short cars produced similar stresses on spans of 24' 4", 31' 10", and 55' 5" when compared to the standard 53-foot cars.
- Slightly higher deflection at mid-span was found on the 64' 8" span due to short cars when compared to the standard length cars.
- In terms of fatigue, for all four spans tested, the fatigue due to short cars was no worse than that due to standard 53-foot cars.

Testing at FAST was conducted to determine differences in bridge responses due to two car types and to confirm the analytical results. Moreover, the testing was performed to measure effects on subgrade and evaluate vehicle performance. However, the analysis presented in *Technology Digest* TD-16-013, "Short Heavy Axle Load Cars: Analysis," shows that the short cars can create significantly larger stresses, when compared to standard length cars for spans of 80 feet and longer. It is recommended that future research consider testing of longer bridge spans under unit train traffic with different length cars.

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INTRODUCTION

TTCI is investigating the effects of HAL traffic on infrastructure, specifically as related to minimum length interchange cars. For the purpose of this study, HAL cars are considered to be cars with a gross rail load of 286,000 pounds or more. Data from the railroad industry equipment database, UMLER®, shows the number of HAL cars shorter than 48 feet have increased from 40,000 to more than 85,000 during the last 5 years, and the majority of these short HAL cars are covered hoppers approximately 42 feet long. The areas of particular focus are those that might be different for cars of minimum interchange length (about 42 feet) as compared to the common 53-foot coal cars that have been used in previous HAL studies. Preliminary studies identified embankments and bridges as the most likely areas of concern.

This *Technology Digest* focuses on field tests of bridge performance under short cars and typical 53-foot cars conducted at FAST.

TESTING AT FAST

A member railroad provided 12 short HAL cars for testing at FAST to determine the differences in bridge response in comparison to standard length cars (e.g., 53-foot coal gondola or open-top hopper). The test train included 1 locomotive; 1 instrumentation car (passenger car); 12 covered hoppers (approximately 42 feet long, weighing 286 kips); 6 coal gondola or open-top hoppers (53 feet, 286 kips); and 6 coal gondola or open-top hoppers (53 feet, 315 kips). The test train is presented in Figure 1.

Figure 1. Test Train

Test runs were made at 10, 20, 30, 40, and 45 mph to evaluate the effects of the different car types at various speeds. For each speed, two to three train passes were made in each direction. In addition, runs were made at 2 mph over all bridges.

The test included many components: collection of wayside data using the FAST Truck Performance Detector system (to evaluate vertical and lateral forces), stresses and deflection measurements of all four steel spans at FAST, instrumented wheelsets (IWS), and geotechnical transducers in the low track modulus section. Figure 2 is a photo of a short HAL car and a standard length HAL car on one of the steel bridges.

Figure 2. Short Cars (top) and Standard Length Cars (bottom) on Steel Bridge at FAST

TEST RESULTS

Strains and displacements were recorded for all spans. The strain gages were placed at mid-span and quarter point locations while the displacements were measured only at mid-span. The train ran in both directions over the bridges at various speeds. Figure 3 presents typical stress histories for all four spans recorded during the test. Peaks in the red box are due to short cars of 286-kip weight, those in the green box are due to long cars of 286 kips and 315 kips. The maximum peaks were found and averages of maximum peaks were calculated for each car type at different speed.

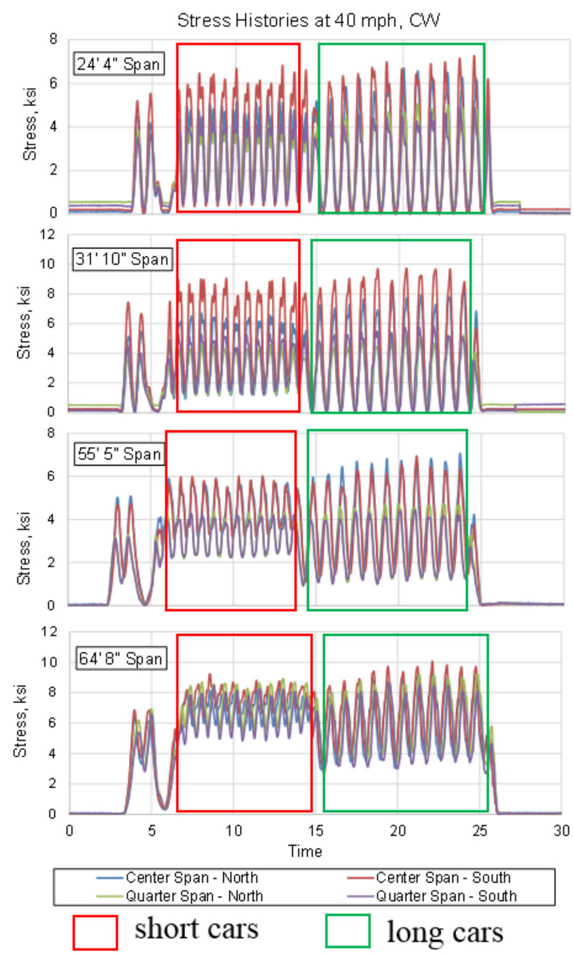

Figure 3. Test Train Stress Histories for FAST Steel Spans

It should be noted that each pressure pulse shown includes four wheels under two adjacent trucks from adjacent cars, and each valley corresponds to the distance between two trucks under a single car.

Peaks were analyzed and average peak stresses were calculated for each data set. Figure 4 presents a comparison of peak stress at four span locations. As shown in this figure, there is no significant difference in magnitude of peak stresses measured under train operations with two different car lengths. The only noticeable difference in stress magnitude is for the 315-kip car, which was expected.

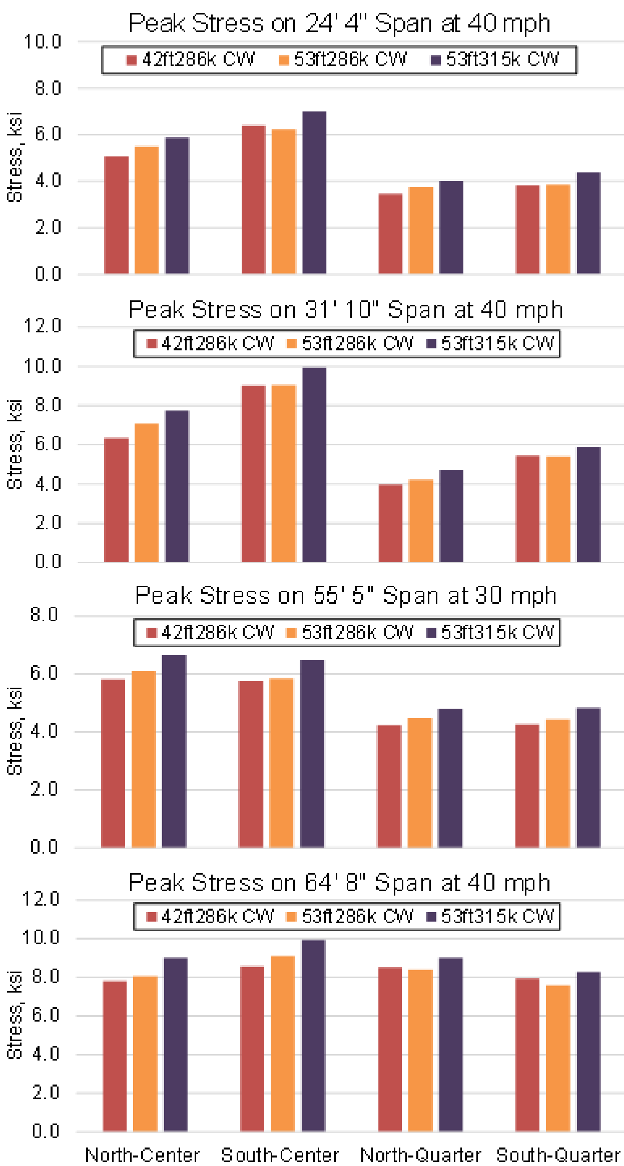

Figure 4. Comparison of Average Maximum Stress (ksi) of Three Car Types at Four Span Locations

The analysis presented in TD-16-013 indicated that the longest span at FAST (64' 8") had slightly higher moment (about 5 percent) due to short cars as compared to standard length cars. Finite element analysis (FEA) modeling of the 64' 8" span shows a negligible difference at the center of the span, but visible effects at quarter span locations (about 7 percent higher). The field data confirmed that the quarter span location of the 64' 8" span has slightly higher stresses due to short cars when compared to stresses due the standard length car (about 4 percent). However, the measurements also show a small variation between north and south girders.

The effect of the direction was very minimal and it may be considered to be within the tolerance of the measurement. The influence of speed on spans located on tangent track was also minimal, as can be seen in Figure 5. The variation of stresses due to train speed is noticeable on the spans located on the curve. This variation, however, is correlated to the superelevation and it is consistent through both spans and for all four locations. An example of the speed effect at spans with superelevation is shown in Figure 6.

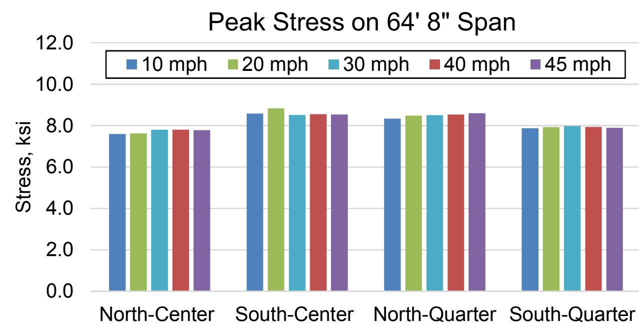

Figure 5. Comparison of Average Maximum Stress (ksi) of Short Car at Various Speeds for 64' 8"Span

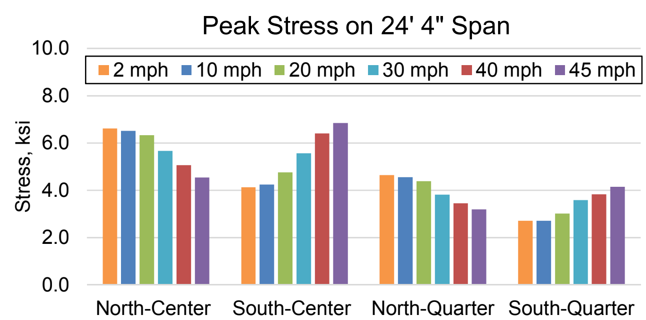

Figure 6. Comparison of Average Maximum Stress (ksi) of Short Car at Various Speeds for 24' 4" Span

FATIGUE EVALUATION

Equivalent moment ranges were also calculated based on moment histories developed for each span length and due to various car types. Figure 7 provides the equivalent stress range comparison.

In terms of fatigue evaluation, detrimental effects of shorter cars were not observed. For all spans, 53-foot standard length cars caused larger equivalent moment ranges due to larger intermediate cycles. On shorter spans, longer truck spacing in 53-foot cars caused intermediate cycles to be full range cycles, from 0 to peak stress. This can be seen in Figure 3 for 24' 4" and 31' 10" spans. Stress histories for the longer spans also show that the intermediate cycles are higher due to the 53-foot cars. Comparison of equivalent stress ranges due to three car types at four span locations is presented in Figure 7.

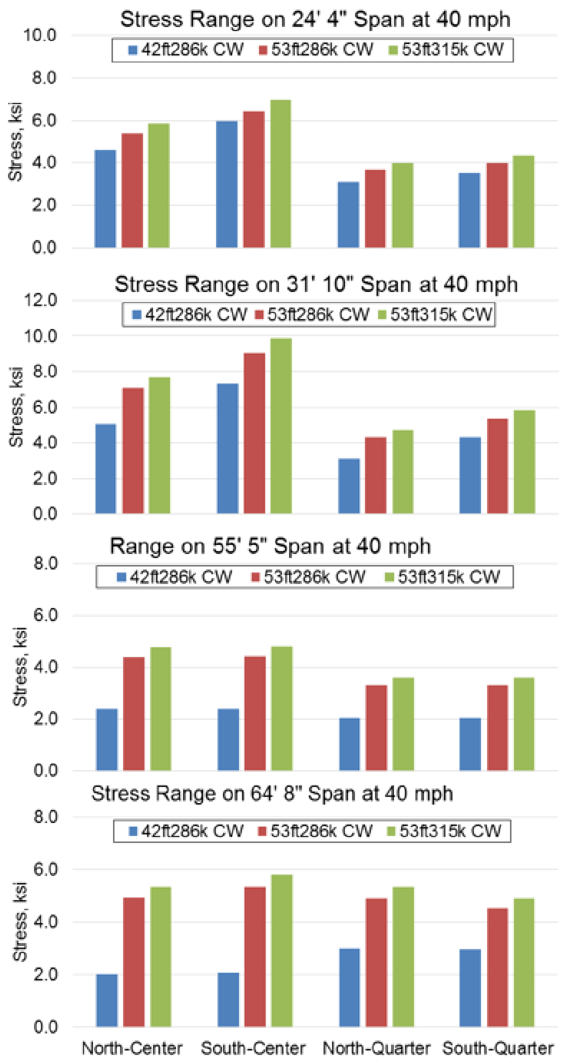

Figure 7. Comparison of Equivalent Stress Range (ksi) due to Three Car Types at Four Span Locations

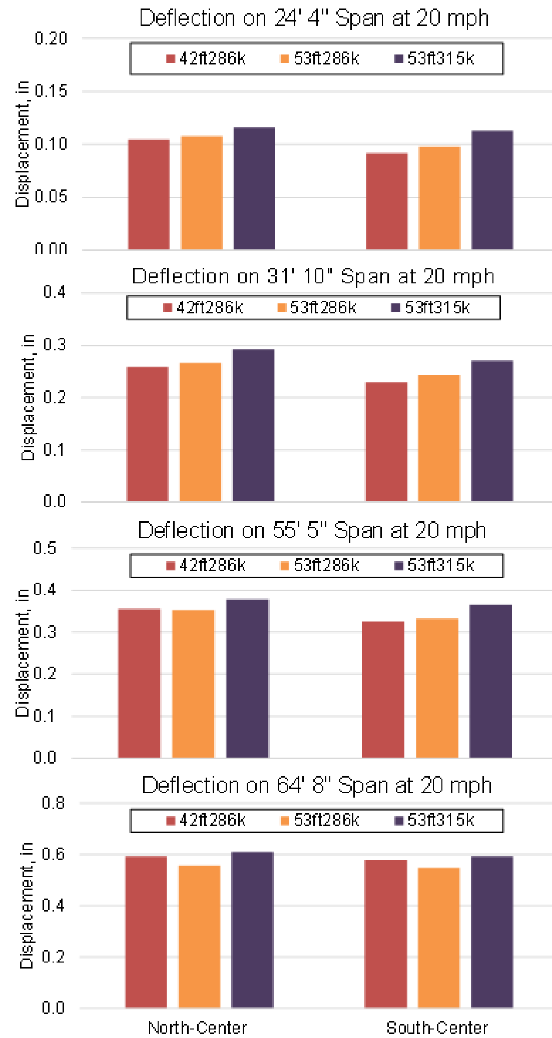

Figure 8. Comparison of Maximum Deflections (in) Due to Three Car Types at Mid-span for Spans at FAST

DEFLECTION

Displacement was recorded for all spans at FAST at mid-span locations. The maximum peaks were found and averages of maximum peaks were calculated for each car type at different speed. The results are presented for 20 mph in Figure 8. The deflection peak of the 64' 8" span has a slightly higher magnitude, about 4 percent, due to short cars when compared to the standard length cars.

CONCLUSION

The test data confirmed analytical calculations that short cars do not cause larger maximum stresses on the relatively short spans at FAST measuring 24' 4", 31' 10", 55' 5", and 64' 8". Only slightly higher stresses, about 4 percent, were observed on the longest span at FAST (64' 8") at the quarter point due to short cars when compared to the standard length cars. Also slightly higher deflection at mid-span was found on the 64' 8" span.

Effective moment range, used for fatigue evaluation, was observed to be higher for all spans due to standard length cars. This higher effective moment range would result in a shorter fatigue life.

FUTURE RESEARCH

It is recommended that future testing be done on longer bridge spans under unit train traffic with different length cars. It is suggested to perform the structural analysis before field measurements since it is possible that the higher stresses can be found at other than the mid-span locations.

REFERENCES

1. Rakoczy, Anna, Duane Otter, and Stephen Dick. April 2016. “Short Heavy Axle Load Cars: Analysis.” *Technology Digest* TD-16-013, TTCI/AAR, Pueblo, Colorado.