TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 4269-S

Project 0-4269: Accounting for Large Trucks in the Design of Signs and Pavement Markings

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PROJECT SUMMARY REPORT

Effects of Vehicle Type on the Nighttime Visibility of Signs and Pavement Markings

In Texas, commercial vehicle safety is an increasing priority due to the rising volume of truck traffic and the disproportionate percentage of crashes and fatalities involving large trucks. One particular safety issue is the visibility of signing and pavement markings at night from a commercial vehicle driver's perspective.

In theory, commercial vehicle drivers are at a disadvantage when it comes to the amount of light returned from retroreflective devices such as signs. This is because the eye/headlamp separation in large trucks is substantially greater than in other types of vehicles, and the performance of retroreflective materials generally decreases as the eye/headlamp separation increases. This report summarizes research conducted by the Texas Transportation Institute (TTI) to determine to what extent, if any, this theoretical disadvantage actually affects the visibility of retroreflective signing and pavement markings at night.

What We Did . . .

Researchers first conducted a survey of commercial vehicle drivers in order to solicit opinions and identify commercial vehicle drivers' concerns with the signs and pavement markings currently used on state roadways maintained by the Texas Department of Transportation (TxDOT). This survey targeted commercial vehicle drivers with varying levels of experience, age, and miles traveled per year. A total of 121 surveys were administered at truck stops on I-35 in Buda, on I-45 in Huntsville, and on I-10 in Brookshire.

Next, a nighttime controlled field study evaluated the relationship between vehicle type (passenger car versus commercial vehicle), sign material (American Society of Testing and Materials [ASTM] Types III, VIII, and IX), and pavement marking material (approximately 100, 300, and 800 mcd/m^2/lux) in terms of the legibility distance of signs and

Figure 1. 1986 Freightliner

Figure 2. 1998 Chevy Lumina

the end detection distance of pavement markings. Based on the results of the commercial vehicle driver survey, researchers used four different sign types (guide, destination, daytime speed limit, and nighttime speed limit) during the evaluation. In total, 28 truck drivers viewed 33 sign treatments and six pavement marking treatments in a 1986 Freightliner Model C12064ST (tractor only), as well as in a 1998 Chevy Lumina (Figures 1 and 2, respectively).

Finally, the research team performed a headlamp study to determine the headlamp illuminance (i.e., amount of light reaching an object) of on-road commercial vehicles and to assess how representative the 1986 Freightliner was in terms of headlamp illuminance. The illuminance of 10 commercial vehicles' headlamps was measured at locations representing four typical sign placements (including the average location of the signs in the controlled field study). Researchers also measured the headlamp illuminance of the two study vehicles used in the nighttime controlled field study.

What We Found . . .

The results of the survey showed that 46 percent of the commercial vehicle drivers are primarily concerned with the construction or maintenance of Texas roadways versus 9 percent who are primarily concerned with signs and pavement markings. In addition, 58 percent of the commercial vehicle drivers surveyed did not identify any problems with the signs and pavement markings currently being used in Texas.

Only after being specifically asked about the "brightness" of the signs and pavement markings used in Texas did 62 percent of the participants state that they had a concern. Even though most of these concerns focused on the driver's ability to see the signs and/or pavement markings at night, only 5 percent of those surveyed felt that Texas roadway signs were difficult to see at night. Interestingly, 60 percent of the Texas resident commercial vehicle drivers surveyed felt that there was no difference in the brightness of signs and/or pavement markings when driving a commercial vehicle versus a passenger vehicle. In addition, only 20 percent of the Texas resident commercial vehicle drivers surveyed felt that signs and/or pavement markings appear brighter in a passenger vehicle.

The controlled field study results showed that the average legibility distance of the commercial vehicle was 4 to 12 percent greater than the average legibility distance of the passenger car. In addition, the type of retroreflective material was found to be a significant factor for the speed limit signs and the pavement markings, but not for the guide signs or destination signs. For the daytime (white) speed limit signs, the average legibility distance for the Type IX sheeting was 3 to 6 percent longer than that of the Type VIII and Type III sheeting, respectively. For the nighttime speed limit signs, the difference between the average legibility distance for Type IX sheeting and Type III sheeting was practically negligible (only approximately 1 percent). In contrast, the average legibility distance for Type VIII sheeting was approximately 5 percent less than that of the Type III and Type IX sheeting.

However, as shown in Figure 3, the researchers found a clear relationship between pavement marking retroreflectivity and end detection distance. Figure 3 demonstrates that increasing the pavement marking retroreflectivity from 100 mcd/m^2/lux to 300 mcd/m^2/lux increased the average end detection distance by 41 percent. Increasing the retroreflectivity from 300 mcd/m^2/lux to 800 mcd/m^2/lux increased the average end detection distance by 23 percent.

With respect to the research objective, the relationship between vehicle type and material type was of prime concern. This relationship was found to be statistically significant only

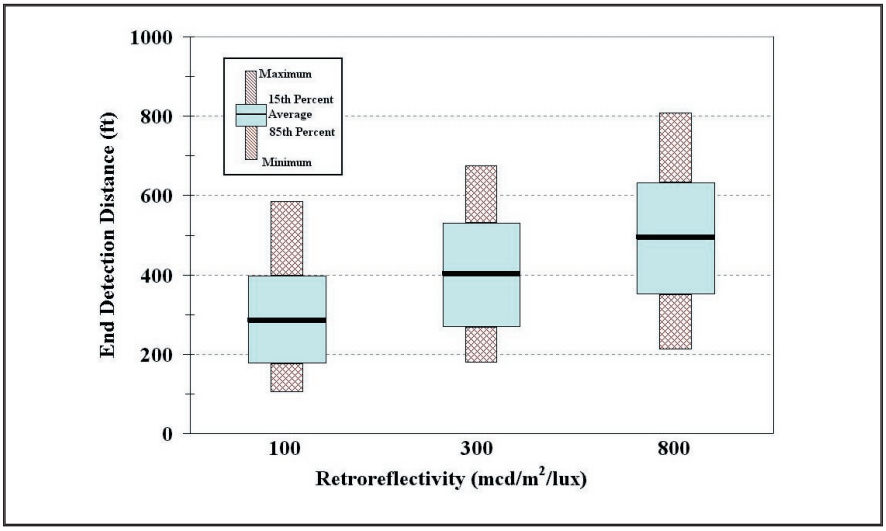

Figure 3. Relationship between Pavement Marking Retroreflectivity and End Detection Distance

for the speed limit signs, and even then the practical difference in the legibility distance between material types as a function of vehicle type was small. For the daytime speed limit signs, the Type IX sheeting produced the largest increase in legibility distance for the commercial vehicle compared to the passenger car. This same finding was not replicated for the nighttime speed limit signs. Furthermore, the relationship between vehicle type and material type for the nighttime speed limit signs was less distinctive in terms of performance differences.

As shown in Figure 4, the headlamp illuminance of the Freightliner used in the nighttime controlled field study was consistently greater than the average headlamp illuminance of the 10 commercial vehicles that were measured. In addition, the luminance returned to the driver of the Freightliner from a right shoulder-mounted sign (which represents the average location of the signs in the nighttime controlled field study) was greater than the luminance returned to the driver of an average on-road commercial vehicle, but comparable to that returned to the Chevy Lumina driver (Figure 5). Thus, the amount and pattern of light emitted by the Freightliner's headlamps increased the amount of light falling on the signs (illuminance), which in turn reduced the disadvantage associated with the larger eye-headlamp separation of commercial vehicles and increased the amount of light returned to the driver (luminance). This higher than expected luminance allowed the participants in the Freightliner to read the signs farther in advance than expected. This hypothesis supports the results of the nighttime controlled field study.

The Researchers Recommend . . .

Neither the sign nor pavement marking findings revealed consistent relationships between vehicle type and material type. For the legibility of signs, the relationship between vehicle type and sheeting type was found to be statistically significant only for daytime and nighttime speed limit signs, and even then the practical difference was small. For the end detection of pavement markings, the study revealed no statistical or practical relationship between vehicle type and material type. However, the study clearly showed that brighter pavement marking materials benefit drivers of both vehicle types.

Since no consistent relationship was revealed between vehicle type and either sign sheeting or pavement marking materials (as measured using nighttime driver performance), TxDOT can make decisions about its sign sheeting and pavement marking materials without necessarily being concerned about any specific vehicle type. In other words, for the scenarios studied, no specific considerations with respect to sign sheeting and pavement marking materials are needed for passenger car drivers or commercial vehicle drivers. The researchers recommend that TxDOT install and maintain pavement marking materials at the highest retroreflectivity level feasible.

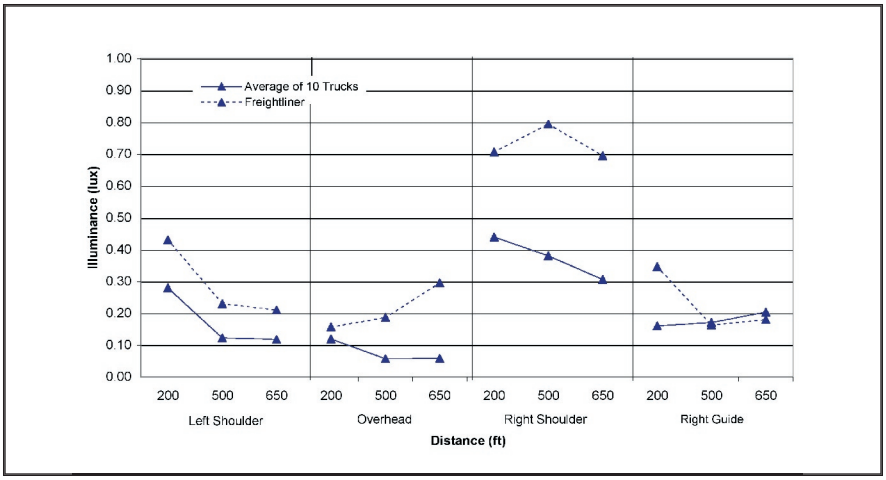

Figure 4. Commercial Vehicle Headlamp Illuminance (Both Headlamps)

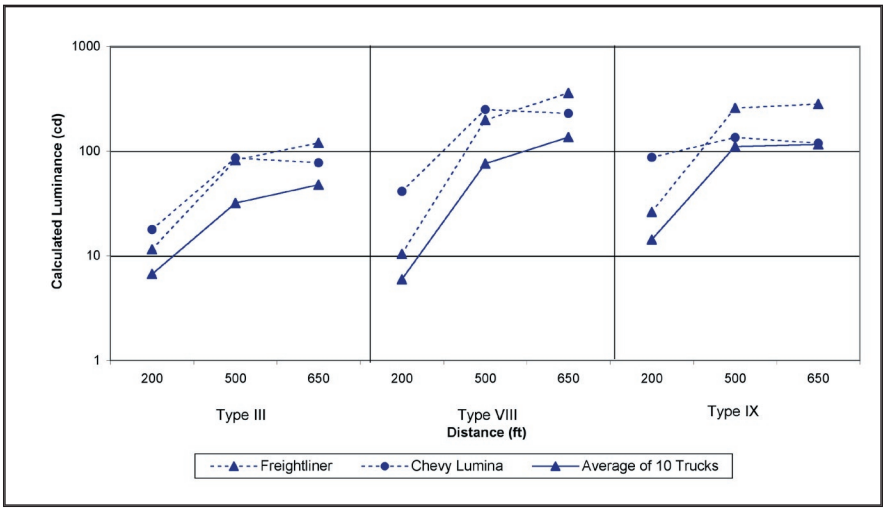

Figure 5. Luminance Values for a Right Shoulder-Mounted Sign

For More Details . . .

The research is documented in the following report:
4269-1 *Sign and Pavement Marking Visibility from the Perspective of Commercial Vehicle Drivers*

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TxDOT Implementation Status
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This research project examined commercial vehicle safety issues; in particular, the visibility of signing and pavement markings at night from a commercial vehicle driver's perspective. One product was required for this project: recommended changes to TxDOT traffic control standard sheets. Results of this research indicate that the materials used for retroreflective signs and pavement markings provided adequate levels of luminance from the perspective of commercial vehicle drivers while still meeting the needs of passenger vehicle drivers. Based on these results, changes to the TxDOT standard sheets are not warranted.

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