
Research Report
KTC-93-8

**EVALUATION OF DIAMOND GRADE
REFLECTIVE SHEETING**

by

Kenneth R. Agent
Transportation Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky

in cooperation with

Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

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16. Abstract The objective of this project was to monitor the performance of the diamond grade sheeting when used on both typical traffic signs and construction signs. The durability, appearance, and reflectivity of the signs were monitored. Diamond grade sheetings used on typical traffic signs were evaluated over a two-year period with construction signs evaluated over an 18-month period. Diamond grade sheeting was found to provide increased reflectivity compared to high intensity sheeting with no problems noted related to durability or appearance. However, the cost of the diamond grade sheeting would limit its use to situations where brighter, wider-angle reflective sheeting is warranted and the increased cost can be justified. Locations where the use of diamond grade sheeting should be considered because of its higher reflectivity include the following: 1. signs in areas with high levels of ambient lighting, 2. work zones (especially in urban locations) where the roadway environment is visually cluttered, and 3. high accident locations involving a nighttime accident problem. A location where use of diamond grade sheeting could be considered because of the increased viewing angle would be for overhead signs in urban areas. These increased angles would only be a factor when the driver is attempting to view the sign at a locations close to the sign which could be the situation at urban intersections.					
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INTRODUCTION

The age of the general driving population is increasing. One problem associated with the older driving population is nighttime vision. It has been documented that the visibility of a given sign to a group of drivers will decrease with driver's age. One potential method to increase the visibility of signs is to increase their brightness.

Work zones present a unique problem in the area of traffic control. Nighttime conditions present even more of a problem. Traffic control in work zones should provide advance warning, make the work area visible, and provide directions. To accomplish this, the traffic control devices must provide maximum visibility to the driver.

High intensity sheeting is currently used by the Kentucky Transportation Cabinet on all typical traffic signs as well as signing and barricades in work zones. The high intensity sheeting has been manufactured by 3M. Diamond grade sheeting is a new material which has been developed for the purpose of providing improved visibility. This material is also manufactured by 3M. The diamond grade sheeting is brighter than high intensity sheeting. It is also designed for wide-angle brightness which could be of benefit in locations such as work zones where there is the potential for misaligned signs.

This evaluation involved the use of diamond grade sheeting on both typical highway signs and on construction signs. Two signing projects were evaluated. The first project involved the installation of signs at interchanges on Interstate 64 between Louisville and Lexington. The signs included in the test were stop, yield, do not enter, and wrong way signs placed at the end of exit ramps. The second project involved construction signs used on a major reconstruction project on Interstate 75 in Fayette County.

The objective of this project was to monitor the performance of the diamond grade sheeting when used on both typical traffic signs and construction signs. The durability, appearance and reflectivity of the signs were monitored.

INSTALLATIONS

~~The installations of both types of signs were completed in March 1991. The~~
signs placed on the Interstate 64 ramps were regulatory signs. The types of signs included were stop, yield, do not enter, and wrong way. All of these signs are red and white. These signs were fabricated in South Dakota. This type of sign is prepared using a reverse screening process. The sign starts as silver white sheeting and red transparent ink is used. This process results in all of the sign being reflective.

The signs for the construction zone were fabricated in Louisville. The signs were orange in color. They were not the fluorescent orange color which is also available. Several improvements in the production process have been made since the fabrication of these construction signs. Producing these signs was a two-step process. The first process was placing the sheeting on a substrate and trimming. A metal substrate was used rather than the typical plywood substrate used for construction signs. The manufacturer desired to place these test signs on metal rather than plywood to ensure proper adhesion. The manufacturer has since developed an adhesive which allows the placement of the sheeting on plywood. This first process took a longer time than usual because, instead of having a long roll of material to use to press onto the substrate, the diamond grade sheeting was placed individually on each sign. The diamond grade sheeting is now available in rolls.

The second process in the production of the construction zone signs was the screening of the message on the sheeting. The screening process is the same for diamond grade sheeting as for high intensity sheeting. The orange sheeting is screened with non-reflective black ink so the entire sign is not reflective. The diamond sheeting signs had to be spliced because the sheeting is not made in 48-inch rolls. The sheeting was folded and a slight gap was left in the middle to allow for expansion. The manufacturer now states that no gap is necessary. While a 48-inch roll is still not available, a process has been developed for a 48-inch sign using a combination of two smaller rolls. This procedure allows the sheeting to be placed on the substrate at the same production speed as with a 48-inch roll.

The diamond grade sheeting had to be oriented in a certain manner when screening the letters onto the sheeting. Arrows are stamped at certain points in the material to assure that the sign is oriented properly. The arrows show how the sign is to be oriented in the vertical direction.

There were three reasons for an increased cost of the diamond grade construction signs used in this evaluation. One would be the higher cost of the diamond sheeting. Second would be the use of metal rather than standard wood substrate. The third would be the longer time required to place the sheeting on the substrate. However, the sheeting can now be placed on a wood substrate and the fabrication procedure is now the same as for high intensity sheeting. At this time, the only difference in cost between a sign with high intensity sheeting and a sign with diamond grade sheeting should be the difference in the cost of the sheeting material.

A few signs using diamond grade sheeting have been installed by the cities of Louisville and Lexington. All of these signs were originally placed at overhead locations at intersections. The types of signs placed were street name signs, stop signs, and turn prohibition signs. Diamond grade sheeting has also been used for some ground mounted stop signs and some warning signs in Louisville.

EVALUATION PROCEDURE

The material was monitored to determine its performance in the field. The evaluation considered the durability, appearance, and reflectivity of the signs. Visual inspections were made to evaluate the durability and daytime appearance of the signs. The durability evaluation was subjective and was based on observing for problems such as delamination and peeling, cracking, and abrasion. The daytime appearance evaluation was also subjective and was based on a comparison of the the color of the sign with the original color, taking into account changes due to such factors as fading and dirt accumulation.

Reflectivity data were collected using a Model 920 field retroreflectometer manufactured by Advanced Retro Technology, Inc. The retroreflectometer can be used during daylight conditions to obtain reflectivity measurements. The coefficient of

retroreflection of the surface being measured is displayed in units of candelas per footcandle per square foot (cd/ft/sq.ft.). The Model 920 has a fixed measurement geometry of 0.2 degrees observation angle and a minus four degrees entrance angle. The measurement area is approximately one inch. Several measurements were made on each sign. Nighttime observations were also made to evaluate the nighttime appearance of the signs.

Data were taken immediately after the signs were installed and at six-month intervals. This resulted in five sets of data over a two-year evaluation period for the signs placed at interchanges and four sets of data over an 18-month period for the construction signs. The construction was completed and signs were removed after the construction signs had been in service for approximately 18 months.

The overhead signs placed in Louisville and Lexington were also observed during the evaluation period. The appearance and durability of these signs were observed. No retroreflectometer data could be taken on the overhead signs but nighttime observations were conducted.

RESULTS

Durability

Visual observations of the signs were made on a regular basis over the two-year evaluation period. No durability problems were noted. There was no evidence of delamination or peeling, cracking or abrasion. The splicing of the diamond sheeting on the 48-inch construction zone signs did not cause a durability problem.

The only problem related to durability noted by the construction contractor was that the signs were easily scratched when moved. The contractor typically uses a wood substrate for construction signs, and the scratching of the signs was related to the use of a metal substrate. This problem can now be eliminated since diamond grade sheeting can be placed on a wood substrate.

It has been stated that, with the same substrate, the diamond sheeting should be more durable than high intensity sheeting for construction signs that are moved regularly. This increased durability would be related to the difference in the

encapsulated lens sheeting used in high intensity sheeting versus the prismatic lens sheeting used in diamond grade sheeting.

Appearance

Visual observations of the daytime appearance of the signs were made along with the durability observations. The subjective evaluation did not reveal any appearance problems. No evidence of color fading was noted. The only negative comment concerning the daytime appearance of the orange signs was that the sign using standard diamond grade sheeting was more difficult to read than a similar sign using high intensity sheeting. A fluorescent orange sheeting is now available which increases the daytime visibility of the orange sign.

Reflectivity

Reflectivity data were taken with the retroreflectometer at six-month intervals during the evaluation period. A summary of these data is shown in Table 1. The data show the sheeting has maintained its high level of reflectivity over the evaluation period. All measurements are given in units of candelas per footcandle per square foot. The measurements were taken at an observation angle of 0.2 degrees and an entrance angle of minus four degrees.

Following is a discussion of the results of the reflectivity data. Units are not given but all measurements are in units of candelas per footcandle per square foot at an observation angle of 0.2 degrees and an entrance angle of minus four degrees. In order to have a comparison, the reflectivity data obtained as part of this study were compared to data taken as part of the SASHTO Regional test facility. It should be noted that the SASHTO data were used only for comparison purposes and data continue to be taken as part of the SASHTO Regional test facility process.

The white diamond grade sheeting maintained consistent measurements of over 900 and above for the two-year evaluation period. This compares to the manufacturer's minimum specification of 800 for white diamond grade sheeting. The Kentucky specification for white high intensity sheeting requires a reflectivity level

of 250. Data concerning the reflectivity of various sign sheeting materials have been collected for the past few years by SASHTO at regional test facility locations. Data taken on the SASHTO test panels resulted in measurements of 300 to 400 for white 3M high intensity sheeting and Stimsonite high performance sheeting and 1,200 for white diamond grade sheeting after two years exposure.

The orange diamond grade sheeting maintained a level of at least 500 over the evaluation period. This compares to the manufacturer's minimum specification of 450 for orange diamond grade sheeting. The manufacturer's minimum specification for the fluorescent orange sheeting is 200. The Kentucky specification for orange high intensity sheeting requires a reflectivity level of 100. Data, taken after two years exposure, taken on the SASHTO test panels resulted in measurements of about 130 for orange 3M high intensity sheeting and 200 for Stimsonite high performance sheeting.

The red diamond grade sheeting maintained a level of 170 to 190 over the evaluation period. This compares to the minimum requirements of 35 given in the Kentucky specification for red high intensity sheeting. Data taken on the SASHTO test decks, after two years in service, resulted in measurements of about 170 for white diamond grade sheeting with red ink compared to 40 to 50 for 3M high intensity sheeting and slightly over 30 for Stimsonite high performance sheeting.

Visual nighttime inspections were made to observe the reflectivity of the diamond grade versus high intensity sheeting. When viewed separately, most observers could not note significant differences between signs using both types of sheeting. However, the construction contractor noted a significant difference in the appearance of the signs when used together at a lane closure. Care was taken not to use the diamond and high intensity sheeting in the same lane closure because of the large difference in reflectivity.

SUMMARY

The diamond grade sheeting performed well. No significant appearance or durability problems were noted. The reflectivity of the diamond grade sheeting was much higher than high intensity sheeting. This high level of reflectivity was maintained over the evaluation period. However, when viewed separately at night in a rural environment, observers could not note a significant difference between signs having diamond grade and high intensity sheeting. This suggests that the increased reflectivity would only be beneficial at critical locations.

The cost of diamond grade sheeting must be considered when determining its potential for use. For the construction signs fabricated for this project, the cost of the signs using diamond grade sheeting was approximately twice that for a sign with high intensity sheeting. Changes made in the production process since the fabrication of these signs would result in the only difference in cost being the difference in the cost of the sheeting material. For example, if a construction sign cost \$80 with high intensity sheeting, the cost of the sign using diamond grade sheeting would be about \$115 or an increase of approximately 44 percent. If a 30-inch diamond warning sign costing \$37 using high intensity sheeting, the cost of the sign using diamond grade sheeting would be about \$47 or an increase of approximately 27 percent. The percent difference in price, considering the cost of installation, would be less for the installed sign. The installation cost of an overhead sign would be such that the cost of the sheeting would not be as significant as for a typical ground mounted sign.

RECOMMENDATION

Diamond grade sheeting provided increased reflectivity compared to high intensity sheeting with no problems noted relating to durability or appearance. However, the cost of the diamond grade sheeting would limit its use to situations where brighter, wider-angle reflective sheeting is warranted and the increased cost can be justified. Locations where the use of diamond grade sheeting should be considered because of its higher reflectivity include the following:

1. signs in areas with high levels of ambient lighting,

2. work zones (especially in urban locations) where the roadway environment is visually cluttered and

3. high accident locations involving a nighttime accident problem.

A location where use of diamond grade sheeting could be considered because of the increased viewing angle would be for overhead signs in urban areas. These increased angles would only be a factor when the driver is attempting to view the sign at a location close to the sign which could be the situation at urban intersections.

TABLE 1. REFLECTIVITY DATA FOR DIAMOND GRADE SHEETING

MONTHS IN SERVICE	REFLECTIVITY (CD/FC/SQ.FT)*		
	WHITE	RED	ORANGE
New	900	180	540
6	900	170	500
12	900	180	530
18	940	180	520
24	960	190	**

* Units of candelas per footcandle per square foot.

** The construction project ended after 18 months.