Guiderail Delineation

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This paper investigates delineating guiderails and evaluates the performance of different types of guiderail delineation under a variety of field conditions. A thorough search of literature on the topic determined that virtually no research has been conducted previously on the delineation of guiderails. A determination of the various benefits that could be passed on to the motoring public through delineation of the guiderail is discussed. The installation procedures and the labor involved for each type of delineator or delineation treatment are also discussed. The effects of soil and dirt accumulation on guiderail delineators were measured under different environmental conditions at different geographical locations. Information taken from the results of an actual behind-the-wheel driver evaluation survey revealed that motorists generally respond favorably to guiderail delineation. The selection of an appropriate device for delineating guiderails was based on various performance-related requirements that the device or reflective treatment had to meet. The criteria used for selecting a device for delineating guiderail were ease of installation, resistance to soil, durability, and cost. An improvement in the nighttime visibility of guiderails through delineation should result in a reduction in guiderail accidents, which would help to offset the initial cost of delineation.

The state of New Jersey has approximately 1,039 mi (5,485,920 ft) of guiderails on its state-maintained highway system. The predominant type of guiderail used on New Jersey's state highway system is zinc-galvanized steel W-beam, of which there are some 934 mi. About 75 mi of older cable-and-wood-post guiderail is also present on the state highway system. The steel W-beam guiderail is used on all new installations and is gradually replacing the aging cable guiderail.

More than one variety of guiderail may exist at the county and municipal level. Some installations may include box-beam guiderails or an older version of the W-beam guiderail that may be flared at the top and bottom sections.

Before this research study on guiderail delineation was conducted, a guiderail visibility needs analysis report was drafted (*1*). In this report, attempts were made to to determine the benefits and advantages that guiderail delineation could bring to the motoring public. A reduction in accidents involving guiderails could be one of these benefits. Table 1, which was compiled with information provided by the National Safety Council, presents costs that are characteristic of accidents.

The FHWA classifies guiderails as a typical fixed object hazard (2). Reflectors or delineators can make guiderails more conspicuous during nighttime hours. Enhancing the nighttime visibility of guiderails should increase their detectability and recognition by motorists. Table 2 presents guiderail property damage accidents, fatalities, and injuries for nondaylight conditions during a 3-year period in New Jersey. By using accident data from 1983 to 1984, it was determined that the proportion of total fixed object accidents that involved guiderails increased at night, especially during wet nights.

By using the information supplied in Tables 1 and 2, a total cost of $2,520,000 can be attributed to fatal guiderail accidents from 1982 to 1984. Guiderail injury accident costs amounted to $7,026,200 during this period. Property damages related to guiderail accidents for the same period account for a total cost of $1,282,250 (Table 3). Guiderail-related accident severity and frequency have a direct influence on guiderail repair costs and maintenance. The guiderail repair cost for 1982–1984 on New Jersey state highways was $1,190,133. The total cost figure for guiderail accidents and repair costs for the 1982–1984 period was $12,018,585, or about $4,000,000 per year.

TABLE 1 CHARACTERISTIC ACCIDENT COSTS

Type of Accident	1983 Cost Values ($)
Fatal accident	210,000
Injury accident	8,600
Property damage accident	1,150

TABLE 2 GUIDERAIL ACCIDENTS, FATALITIES, AND INJURIES ON NEW JERSEY STATE HIGHWAYS, 1982–1984

	1982	1983	1984
Fatalities	4	4	4
Injuries	311	255	251
Property damage accidents	372	384	359

TABLE 3 GUIDERAIL ACCIDENT COSTS, 1982–1984

Type	Cost ($)
Fatalities	2,520,000
Injuries	7,026,200
Property damage	1,282,250
Total	10,828,452

Delineating all of the guiderails on the state's highway system would cost about $1,280,000. If a 5-year lifetime is assumed for the delineators, the yearly cost would be $256,000. A 6.4 percent reduction in accidents over a 5-year period would offset the cost of delineation. The cost figure for delineating state-maintained guiderails could be reduced appreciably by development of criteria for delineating guiderails that would suggest when guiderails should be delineated.

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There are many relatively new devices and methods that can be used to delineate guiderails under low light conditions. Most of the devices are intended to increase nighttime visibility of the guiderails. Modern guiderail delineators may utilize various types of reflective sheeting (e.g., encapsulated bead sheeting, cube corner sheeting, etc.) or acrylic prismatic reflectors as their primary reflective component.

Many types of guiderail delineators are mounted to the post bolt of the guiderail. There are also a number of guiderail delineators that affix to the guiderail with an adhesive. Delineator posts that are independent of the guiderail were also evaluated to determine if they could serve as suitable guiderail delineators.

STUDY DESIGN

Five guiderail delineation test sites were selected throughout the state of New Jersey for evaluation and monitoring of 19 different guiderail delineators under a variety of field conditions. One test site was located in northeastern New Jersey, in an area where environmental conditions are relatively severe. Soil, dirt, and oil film accumulate at an accelerated rate at this site. These conditions can provide insight about the effects of dirt and soil on guiderail delineation. Another three guiderail delineation test sites were located in central New Jersey. The final guiderail delineation test site was in southeastern New Jersey, near the coast. One of the reasons for selecting this site was to ascertain the effects that a saltwater environment may have on guiderail delineation. Additionally, because pedestrian traffic is fairly common at this and one of the central New Jersey sites, problems relating to vandalism were investigated at both locations.

Originally, 12 different types of guiderail delineators or delineation treatments were installed at all five test sites during December 1983. Most of the 12 original delineators consisted of devices that mounted in the W-beam of the guiderail. As second- and third-generation guiderail delineators became available, they were installed at the test sites along with the remaining original devices. A majority of the second- and third-generation devices were installed on the top portion of the guiderail or on the top of the guiderail post itself.

All five guiderail delineation test sites were monitored on a monthly basis. The two sites that were subjected to pedestrian activity were monitored on a biweekly basis during the summer months. Five different descriptions or categories of dirt covering were created to indicate the surface condition of each individual device. Table 4 lists the surface description nomenclature that was used while the devices were being monitored. In addition to rating the surface condition of each device or delineator, the physical characteristics (i.e., damage, cracking, chipping, etc.) of each device were also recorded while the test sites were monitored. The first generation of devices was field tested for 38 months. Second-generation devices were field tested for 31 months, and third-generation devices were tested for 12 months.

RESULTS OF THE FIELD DURABILITY STUDY

During the evaluation and durability phase of the project, 22 different guiderail delineators were field tested at five sites.

TABLE 4 NOMENCLATURE FOR SURFACE DESCRIPTIONS

Surface Description	Reflective Surface Area Concealed by Dirt or Soil (%)
Clean	0–19
Light	20–39
Moderate	40–59
Heavy	60–79
Covered	80–100

Each site consisted of five or more subdivided groups with at least 12 delineators in each group. The delineators were arranged in succession in the first group, and this arrangement was then repeated in the four following groups.

Guiderail Delineation in the W-Beam of the Guiderail

The majority of delineators that were installed initially at all of the test sites were mounted in the W-beam of the guiderail. Usually, delineators that mount in this location are attached to the guiderail by a post bolt, but a few are held in place with adhesives.

Guiderail delineators that attach behind the post bolt of the guiderail can be difficult to install. When the post bolt of the guiderail is loosened to accept the delineator, the entire bolt assembly may turn together as one, making the installation process very difficult. At older sections of guiderail, which may not be zinc-galvanized, some of the post bolts may be fused to the locking nut.

Two models of a plastic, trapezoid-shaped guiderail delineator that mounts in the W-beam of the guiderail with adhesive were also field tested. The plastic outer portion of this device experienced cracking and severe breakage at the field evaluation sites (Figure 1). Installation of this particular delineator is more involved than that of some others because the surface of the mounting area must be prepared, and the outdoor temperature must be above 40°F to permit the adhesive to be dispensed easily from the tube.

A treatment of white paint and glass beads in the middle of the W-beam of the guiderail was field tested at each test site.

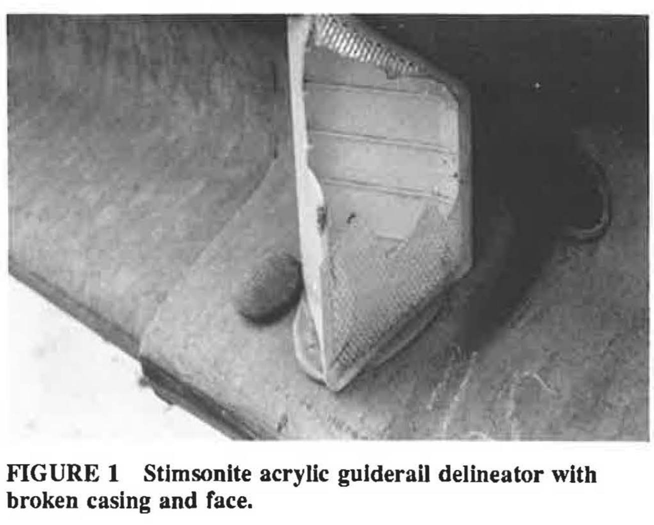

FIGURE 1 Stimsonite acrylic guiderail delineator with broken casing and face.

The paint and glass bead treatment requires a time-consuming surface preparation of the involved area of the guiderail with a steel brush. Another disadvantage of the paint treatment is its poor visibility on tangent sections of guiderail that are aligned parallel to the road edge.

Information from field evaluations and inspections indicates that guiderail delineators mounted in the W-beam accumulate about 23 percent more dirt film than guiderail delineators that mount on top of the guiderail post. The results of this comparison were shown to be significant at the 99 percent confidence level when a *t*-test was performed. Once a delineator in the W-beam is heavily soiled, it is unlikely that the delineator will be sufficiently cleansed by rain because the delineator is shielded by the top portion of the guiderail (Figure 2). Figure 2 demonstrates that delineators mounted both inside and above the W-beam of the guiderail accumulated soil at the same rate for a period of six months. Delineators inside the W-beam remained at or above this level for the next 12 months, while the soil accumulation level for delineators mounted above the guiderail decreased. Delineators mounted in the W-beam of the guiderail become inoperable when snow is pushed against the guiderail during snowplowing operations (Figure 3). Figures 4 and 5 present the percentages of missing and damaged delineators in the test group of delineators that may be used inside the W-beam of the guiderail.

Guiderail Delineators Mounted on Posts Independent of the Guiderail

Two different types of guiderail delineators that attach to steel U-posts with metal rivets were evaluated in the field. One of the delineators tested consisted of an aluminum panel with a face of reflective sheeting. No major problems relating to vandalism or dirt collection were experienced with the reflective panel portion of this device in the field. Another post-mounted delineator evaluated during the field study utilized an acrylic reflective face. Over an 18-month field evaluation period, 43 percent of the acrylic-faced reflectors were damaged and 22 percent of the devices were missing or stripped from the steel supporting posts. (Reflector damage refers to a cracked, broken, or impaired reflector that may still remain functional.)

The steel U-posts supporting both types of delineators were installed independent of the guiderail, behind the guiderail support post. Installing the steel U-post units is a relatively

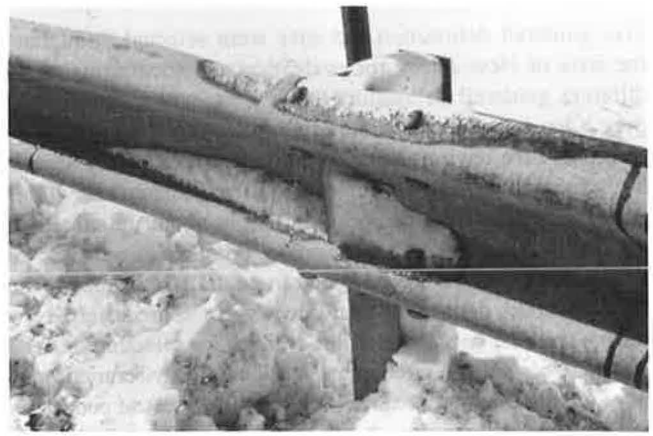

FIGURE 3 Transpo (triangular) delineator mounted inside W-beam of guiderail covered with snow and ice.

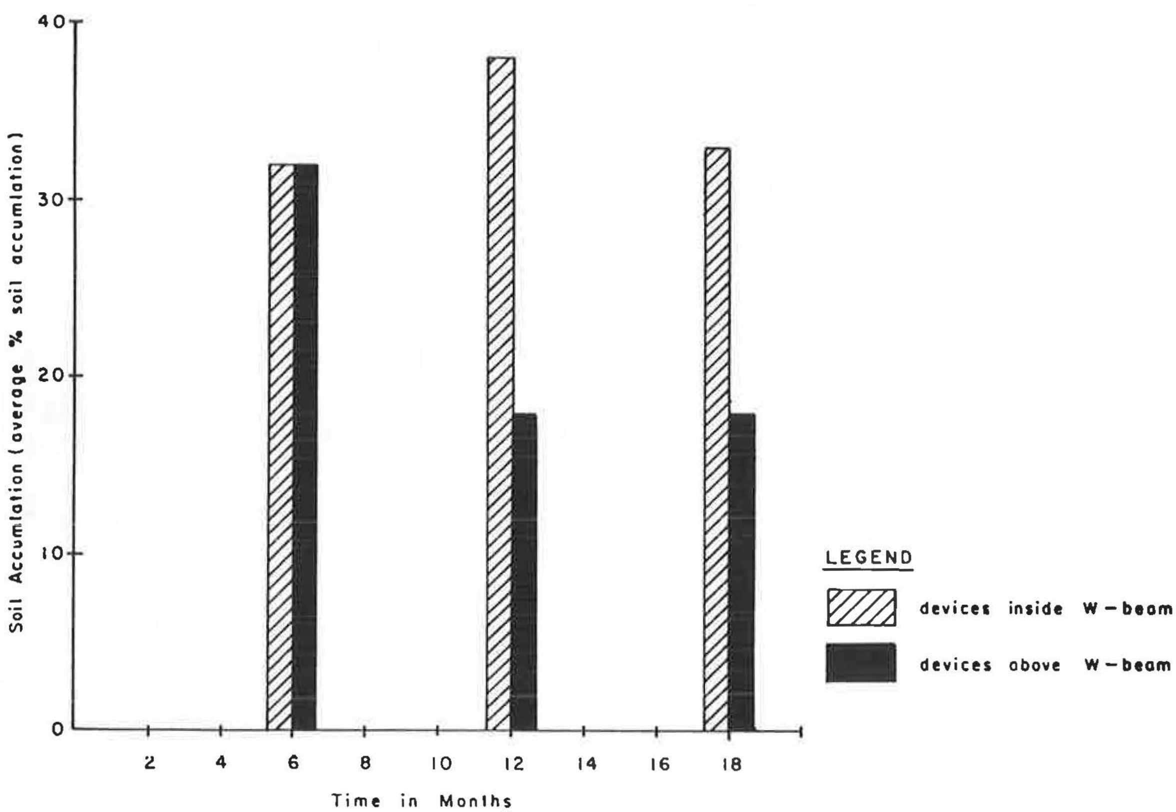

FIGURE 2 Soil accumulation of guiderail delineators inside and above the W-beam.

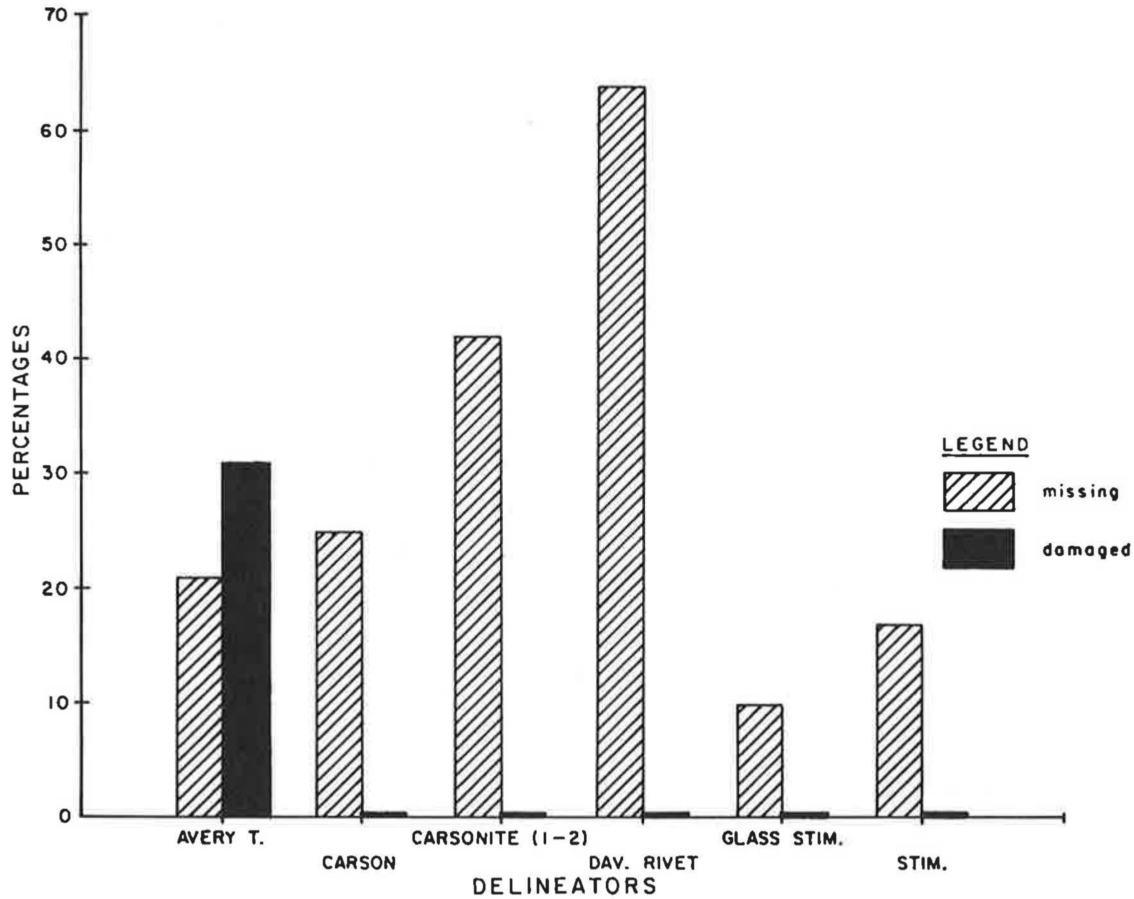

FIGURE 4 Adhesive-mounted delineators found missing or damaged.

strenuous task that requires the use of a large and heavy sledgehammer or slidehammer. In colder weather, the ground often becomes hard, making the installation of the metal post even more difficult. The placement and angle of each delineator post should be determined by the vehicle location and position. A delineator post that is installed improperly, at an incorrect angle to a vehicle's headlights, may be virtually useless. Delineators that are attached to the guiderail are more likely to be placed in the proper orientation to the view of the motorist. Another problem associated with the delineator posts is their vulnerability to lawn mowing and maintenance equipment.

The cost of the galvanized steel U-post, the reflector, periodic maintenance, and the labor involved in installation make post-mounted delineators unattractive for use as guiderail delineators. Delineators that attach directly to the guiderail system eliminate the additional expense and need for an independent mounting post.

Guiderail Delineation on Top of or Above the W-Beam of the Guiderail

A variety of guiderail delineators that attach to or mount on the top portion of the W-beam or on top of the guiderail spacer bracket were also field tested. The delineators that mount on top of or above the guiderail were attached with screws, rivets, or adhesives. If the delineator is to be attached to the guiderail with screws or rivets, a hole must be drilled or punched in the guiderail or post. Drilling these holes requires an electrical power source and equipment, and the whole process demands more effort than attaching the delineators with adhesive or a bracket mounting system.

One of the problems associated with attaching the guiderail delineators with adhesive is the possibility of vandalism occurring in areas that are frequented by pedestrians. Field inspections of some of the delineators that were attached with adhesive revealed instances of the adhesive cracking and separating from the surface of the guiderail. This cracking or damage to the adhesive weakens the adhesive bond between the delineator and the guiderail and makes the delineator more susceptible to vandalism or stress from turbulence. Figure 6 shows an example of damage to adhesive on a guiderail delineator. A manufacturer of one of the adhesives does not recommend application of the material in temperatures below 40°F. In some geographic areas this restriction could delay the installation of delineators for months at a time.

Two types of reflective material that attach to the top bend of the guiderail were field tested. Treatments of paint and glass beads were field tested in this configuration, but there were installation and visibility problems. The glass beads that were applied over the painted surface were not distributed uniformly, compromising the reflective quality of the treatment (Figure 7). Pressure sensitive reflective tape was also evaluated in the field. The tape was difficult to handle during installation and did not adhere well to the cold surface of the guiderail in low temperatures.

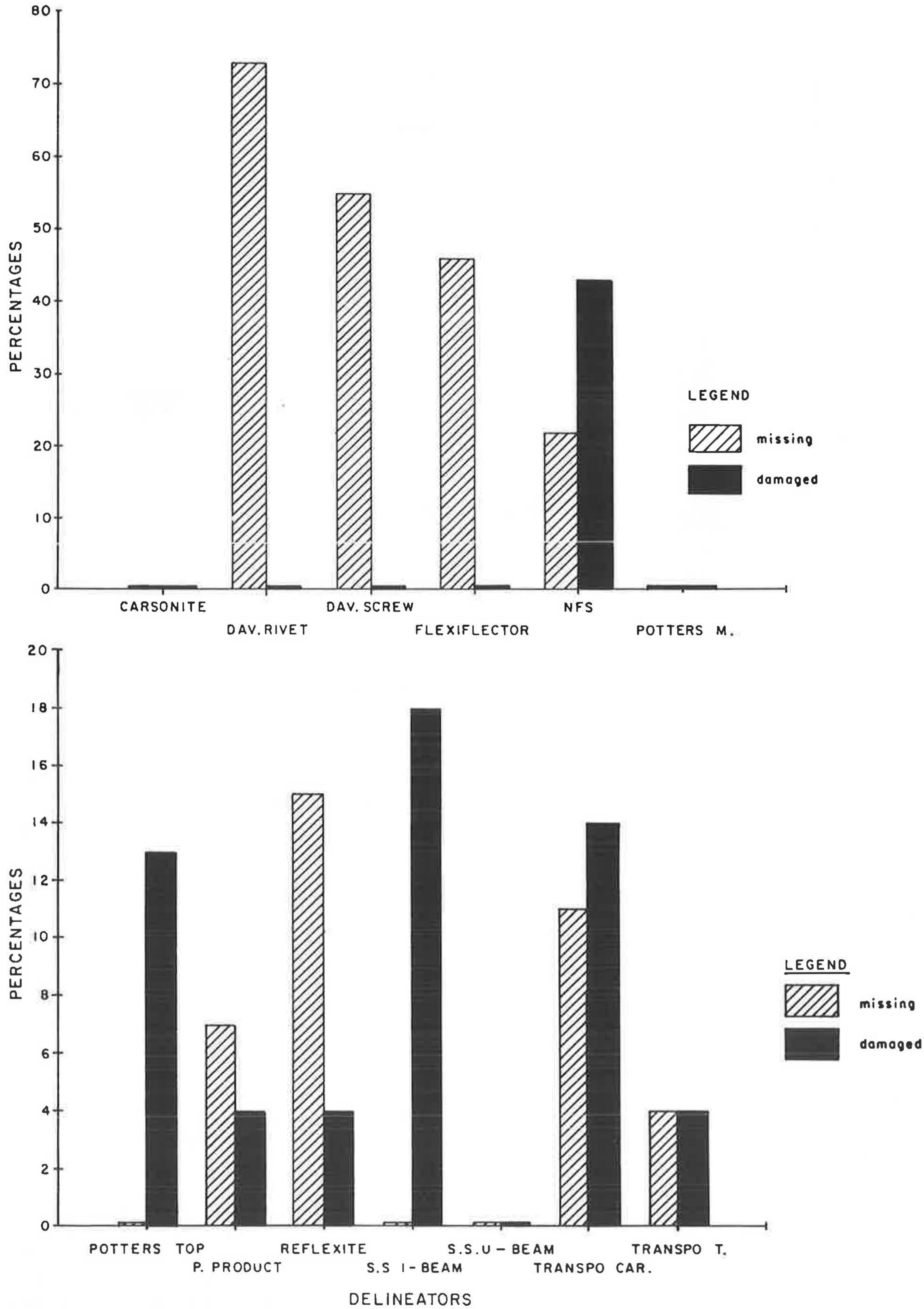

FIGURE 5 Bolt-on and bracket-mounted delineators found missing or damaged.

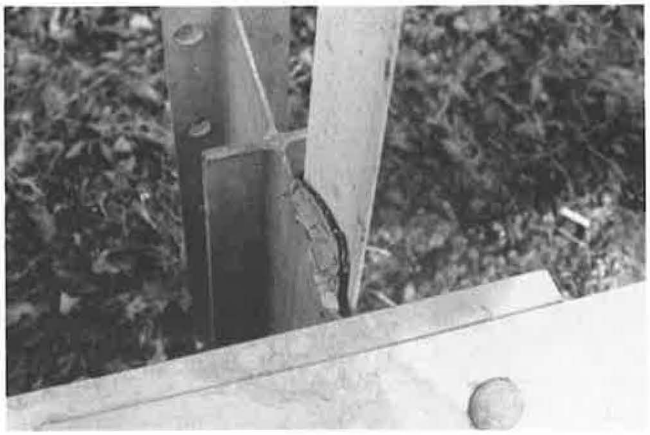

FIGURE 6 Carson delineator panel suffering from cracked and separated adhesive mounting.

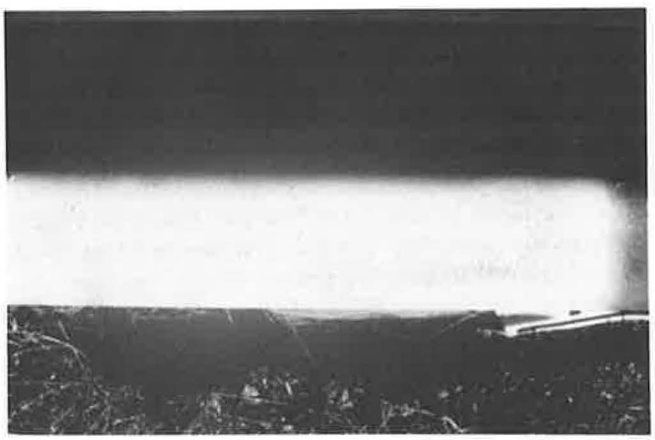

FIGURE 7 Potter's top paint treatment with an uneven application of glass beads over the painted surface.

Bracket-Mounted Guiderail Delineation

A unique two-part guiderail delineator system, which mounts on top of the guiderail post or spacer bracket, was evaluated at each test site. This two-part delineation system consists of a flexible panel and a metal bracket that is secured to the guiderail support post by one or more self-contained bolts. Installation of this delineator is quick and uncomplicated. The only tool required for installation is a small open-end or Allen wrench, depending on which type of bolt is used.

The bracket-mounted guiderail delineators performed well in the field. During an 18-month field evaluation period, none of the devices were lost or damaged at any of the five test sites. None of the bracket-mounted delineators showed any signs of vandalism after this test period.

The 1977 *Guide for Selecting, Designing and Locating Traffic Barriers* (*4*) regulates the material and dimensional characteristics for guiderail installations. Attaching the delineator to a uniform guiderail structure assures a consistent delineator installation. Variables such as placement, offset, and spacing of the delineators can be kept constant by attaching them to the guiderails.

When the bracket-mounted delineator is attached to the guiderail post, the reflector face usually appears to be perpendicular to the roadway; thus a consistent angle of incidence throughout the length of the guiderail is achieved. The mounting height of this particular delineator conforms to the *Manual on Uniform Traffic Control Devices* (MUTCD) (*5*) standards that require roadside delineators to be 4 ft above the near roadway edge.

The height and flexibility of this delineator is an asset, especially during the winter months. As snow is plowed and forced against and above the height of the guiderail, the panel of the delineator system usually remains visible. New Jersey standard specifications require the top of W-beam guiderails to be 27⅝ in. above ground level. The flexible quality of the reflectorized panel enables this delineator system to rebound and to withstand snow and ice that may be hurled from nearby snowplows. This flexibility contrasts with the behavior of certain rigid post-mounted delineators evaluated at the field test sites, which had a tendency to be displaced from their original vertical position. This problem would require periodic maintenance to provide optimum performance.

DRIVER EVALUATION STUDY

The impressions and opinions that motorists have about guiderail delineation was surveyed at six different test sites in the local Trenton, New Jersey, area. Only members of a small segment within the author's immediate divisional group were available as participants for this survey. A limitation on project funds was also a factor in restricting the survey size. The results collected at the test sites are summarized in the following paragraphs.

In a comparison of motorists' responses to field test sites, both with and without delineation treatments, 11 of 18 responses indicated that guiderail delineation was beneficial to drivers. Only 3 of 18 responses showed a decrease in driver responses between the before and after test sites.

Guiderail delineation was shown to be useful in determining the available shoulder space on the roadway. Table 5 presents the responses of participants to the question of whether the guiderail made it easier to determine the usable space of the roadway. The percent responses both before and after delineators were added to the guiderail are given. Recognition of the usable space off the roadway increased at five field test sites after delineators were added to the guiderail.

TABLE 5 RECOGNITION OF SHOULDER SPACE BEFORE AND AFTER DELINEATION

	Test Sites					
	1	2	3	4	5	6
Before delineation (%)	0	67	18	67	10	50
After delineation (%)	27	80	55	83	30	67

No difference before and after delineation was indicated in 4 of a total of 18 driver responses. When delineated guiderail was compared to nondelineated guiderail, it was rated more effective in emphasizing roadway alignment and the road edge at all six test sites. Participants in the survey indicated that delineation of the guiderail was helpful at 4 of the 6 test sites.

In summary, the results from the driver evaluation sites show that guiderail delineation can benefit the motorist through an increase in driver comfort. The results of the survey also suggest that motorists have a high opinion of and support delineation of the guiderail.

SUMMARY

Guiderails are usually installed on highways as a means of protecting motorists from objects or situations that are more hazardous than the guiderails themselves. From 1982 to 1984, guiderail-related accident and repair costs totaled over $12 million on New Jersey state highways.

One objective of this study was to ascertain whether there is a need to delineate guiderails. Determination of a suitable device for delineating guiderails was another objective of the study. A variety of guiderail delineators that mount in the W-beam, on the top of the guiderail, and above the guiderail were field tested. Over a 38-month-long evaluation period, delineators mounted inside the W-beam of the guiderail accumulated more soil than delineators mounted above.

The installation procedure for most guiderail delineators that mount inside the W-beam is labor intensive. The attachment of guiderail delineators with adhesive is unreliable because the adhesive can fail with time. Delineators mounted with adhesive were also vulnerable to damage at locations frequented by pedestrians.

The results of a driver effectiveness study revealed that recognition of the guiderail system increased 16 percent after delineators were added. Of those surveyed, 88 percent rated delineated guiderails as more effective than conventional guiderails in emphasizing roadway alignment and the road edge.

Enhancing the nighttime visibility of guiderails through delineation can increase the detectability and recognition of guiderails. Early detection and identification of guiderails can allow more time for drivers to perform hazard-avoidance maneuvers. Delineation of guiderails could thus help to improve driver comfort during nighttime driving.

CONCLUSIONS

After more than 20 different types of guiderail delineators were evaluated in the field, it was determined that a flexible panel and metal bracket system manufactured by the Carsonite Company was the most suitable device with regard to durability, soil accumulation, and ease of installation. The flexible panel of this system utilizes a face of reflective sheeting, which is a material that has been approved by the New Jersey Department of Transportation. This delineator is one of the few tested that also conforms to MUTCD specifications requiring that the reflector heads of roadside delineators be 4 ft above ground level.

A full investigation of the topic of delineator spacing was beyond the scope of this study. Information that was obtained through driver demonstration sites and a survey of other state practices in guiderail delineation suggests that delineators on curves should be spaced at 37.5-ft intervals (the distance of six guiderail posts spaced 6.25 ft apart) and that delineators on straight sections of guiderail posts should be spaced 75 ft apart (12 guiderail posts spaced 6.25 ft apart). This spacing arrangement is similar to the New Jersey specifications governing the spacing of snowplowable raised pavement markers, which require markers to be spaced 80 ft apart on tangent sections of road. On curves of 3° or greater, markers are placed at 40-ft intervals in accordance with the specifications. Guiderail delineators could be installed on the terminal ends of guiderails, especially those that may lack breakaway cable terminals, in an effort to enhance their visibility.

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