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NEW JERSEY CONCRETE MEDIAN BARRIER DELINEATION

BY

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16. Abstract

A specification for a median barrier delineator developed in a previous research study was used on a four mile section of Route 80 in New Jersey. The installation was monitored over an 18 month period to study the durability of the mounting system, utility of the installation technique, and the nighttime visibility. Problems encountered with the mounting system were as follows: separation of the adhesive from the barrier surface, unusable concrete stud installations, incomplete or improper installation, and vandalism.

The visibility of the delineators was studied at night under dry conditions. Observations were made about the number of devices visible on left and right hand curves, tangents, and lit areas.

A pilot study was performed replacing the washer specified with a larger aluminum plate. After two months of observation no problems with the adhesive separating from the barrier were noticed. Recommendations of the use of a longer concrete stud, more intensive inspection and the use of a rivet to fasten the reflectors to the mount were made to combat some of the other problems encountered.

Based on the observations, changes in the specification attached to the report are recommended.

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NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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BACKGROUND

As a result of a previous research effort on median barrier delineation conducted by the Bureau of Operations Research, a specification for barrier delineators to be used on Route I-80 was recommended to the Division of Design. See Appendix 1.

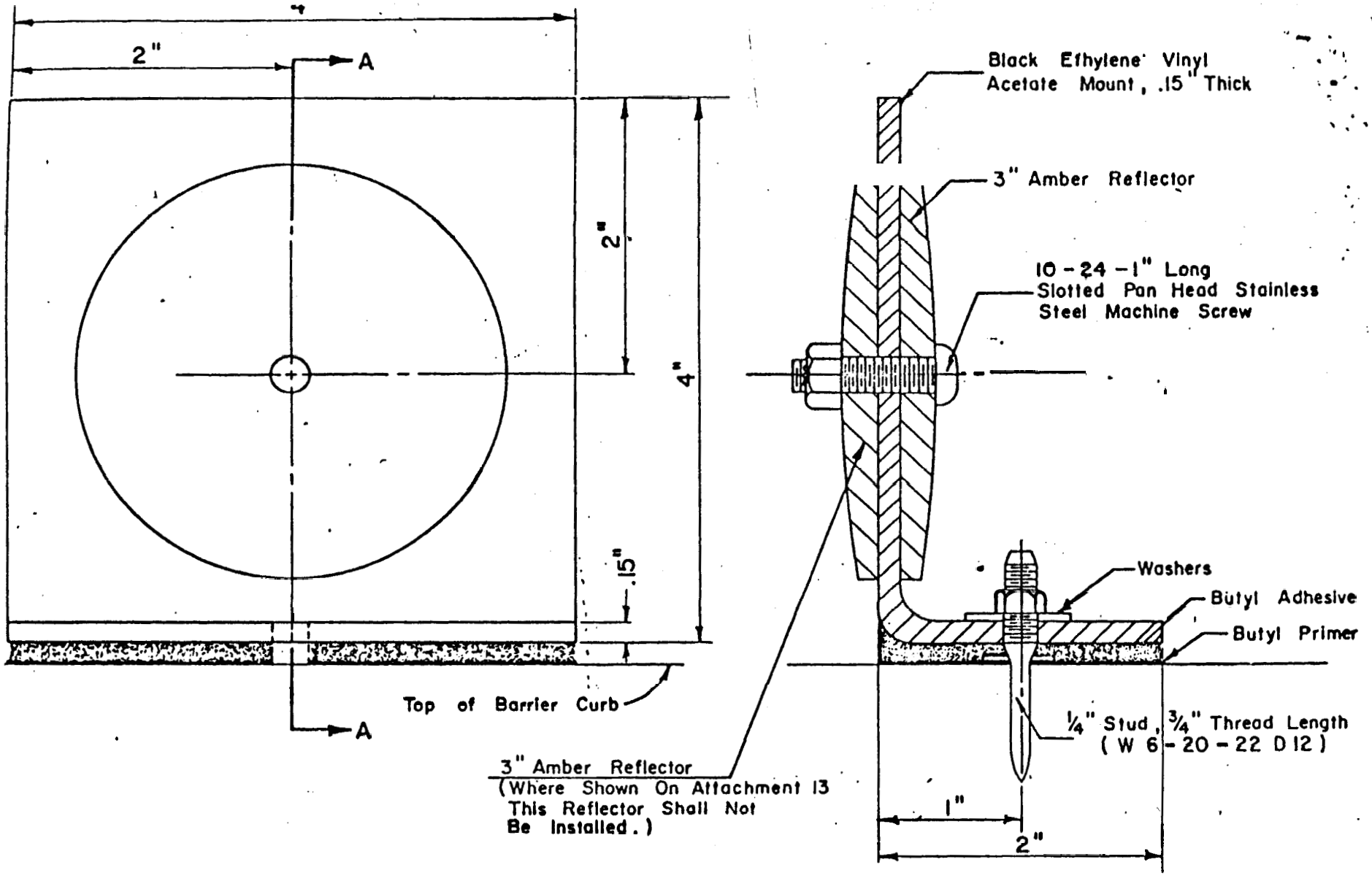
The mounting system recommended (Figure 1) was not tested in our previous research, but is a composite of techniques and materials which were. The decision to use both a concrete stud and a butyl adhesive pad was made to combat problems encountered with the different mounts:

1. Rotation of the mounts around the concrete stud causing loss of view of the reflector. Such rotation did not occur on any of the mounts using the butyl adhesive.[1]
2. The higher loss rate for flexible mounts attached with butyl adhesive than mounts attached with the stud (22 percent vs. two percent).[2]
3. Failure of the stud to remain in the barrier due to rusting. Use of the butyl adhesive will seal the area where the stud penetrates the barrier and prevent water from seeping in.

The use of two studs instead of the butyl adhesive was rejected because problems were anticipated with lining up the concrete studs shot into the barrier with two holes pre-drilled in the flexible mounts. The concrete stud recommended for use has a shorter thread length (3/4" vs. 1-1/2") than the one used in the previous research effort.

The mounting bracket chosen was a black Ethylene Vinyl Acetate mount with dimensions as shown in Figure 1. It was selected because of its superior resistance to damage and permanent deformation when compared to metal mounts and because it would pose less danger to

FIGURE 1



FRONT VIEW

BARRIER CURB DELINEATOR

NOT TO SCALE

NOTE: TO BE INSTALLED ON TOP CENTER OF BARRIER CURB

motorists if it came off the barrier.[3]

The recommended reflector was an amber acrylic cube corner type (Stimsonite 975 or equivalent). Although another device, a convex glass lens type (Swareflex 329), was considered more reflective in the two after studies,[4] the former device was chosen for the following reasons:

1. When new, the Stimsonite 975 was by far rated the most reflective.[5]
2. It is believed that the emergence of the glass device as more reflective after one winter's weathering at the side mounted positions would not occur as quickly on top of the barrier where the rate of reduction in reflectivity due to weathering was much lower.[6]
3. After one winter's exposure, the Stimsonite reflector was rated as being more reflective in the rain, even though the Swareflex was rated as being more reflective under dry conditions.[7]
4. After two winters' exposure, both the Stimsonite and Swareflex reflectors were judged adequate as barrier delineators at all mounting positions.[8]
5. The Stimsonite reflector was less expensive than the Swareflex ($0.27 vs. $1.30 - 1975 prices).

The vertical position selected for use was on top of the barrier. The effects of weathering at this position were significantly less than at the positions on the side of the barrier.[9] This position would allow reflectors for both directions of travel to be placed on the same mount, thus saving installation and materials cost.

The recommended spacing on the barrier was 40 ft. on curves and 80 ft.

on tangents. This spacing was used in the previous research study to coincide with the placement of raised pavement markers and lane lines.

PURPOSE OF THE STUDY

Since the recommended specification included a mounting system never used, it was decided to monitor the installation on Route 80 to determine whether any improvements could be made to the system. Also of interest was the nighttime visual effectiveness of the entire installation since the previous study had only included a short stretch of devices mounted on top of the barrier.

LOCATION

Interstate 80, M.P. 0.0 to 4.3. The site has overhead lighting only at one curved section about 6/10 mile long, and near the bridge over the Delaware River. The site is generally level but with several horizontal curves.

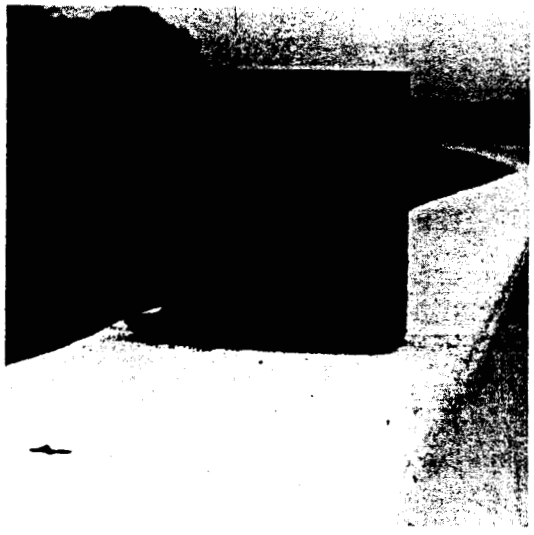
A total of 409 devices were installed between August 1 and December 16, 1977.

SITE INSPECTIONS

December 1977

At this time, not all the devices had been installed so a preliminary inspection of approximately 40 delineators was performed. The following problems with the mounting system were observed:

1. All devices exhibited lifting of the butyl pad away from the barrier surface. This lifting ranged from a slight amount around the edges to more severe cases (see Figure 2). On one device, no bond existed between the adhesive and the barrier,



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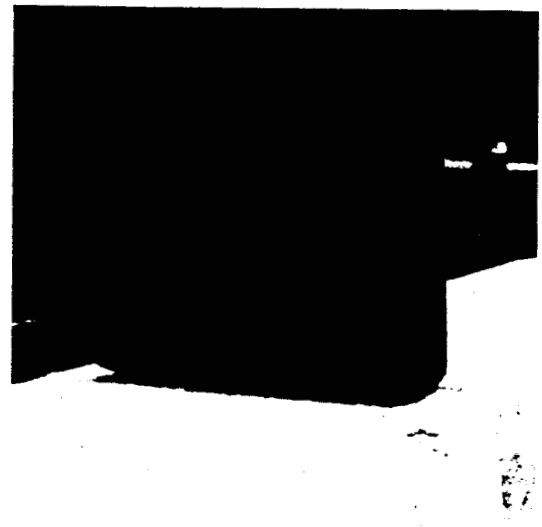

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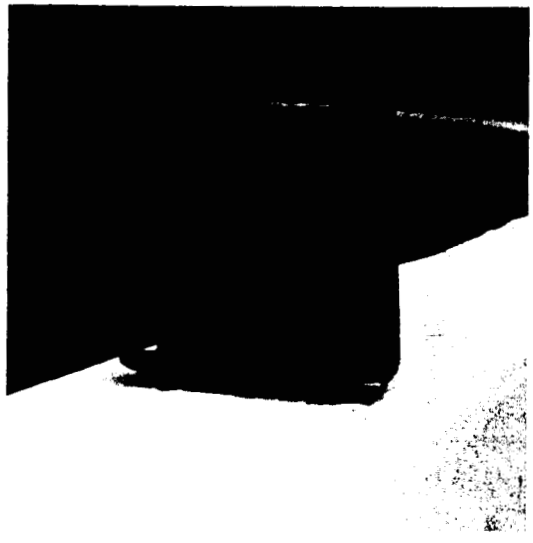


SEVERE >50%

NO ADHESION - MOUNT
ROTATED AROUND STUD

FIGURE 2

EXAMPLES OF SEPARATION OF THE BUTYL
ADHESIVE FROM THE BARRIER SURFACE

enabling the device to rotate around the stud. Frequently, only the adhesive under the nut and washer adhered to the barrier.

2. The mounting brackets did not hold a 90° angle. They were bent about 10° towards the smaller face (see Figure 3). This change was noticed on all devices inspected and on one which was not installed. Apparently the bending was the natural state of the bracket and not due to weathering or exposure.

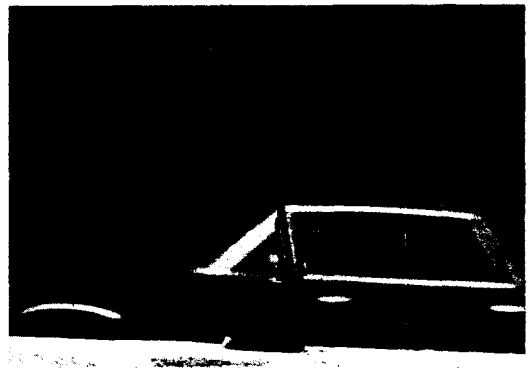


FIGURE 3

EXAMPLE OF BENDING EXHIBITED
BY ALL BRACKETS

3. The studs used were shorter than those employed in the previous research study (3/4" thread - 22mm shank vs. 1-1/2" thread - 27mm shank). About five of the 40 devices inspected had no washer. The bolt penetrated the concrete too far and insufficient thread length was available for use of a washer and nut.
4. In an area where pedestrian traffic is likely to exist (a park on each side of the raod with an underground passageway between them), four out of 12 devices were missing both reflectors. One device looked as if someone attempted to pry the washer off and scrape the butyl from the mount. There was no evidence (i.e., scrape marks on the barrier) of this damage being caused by impacts from vehicles.

The resident engineer, inspector, job foreman and contractor were interviewed to obtain their opinions about the problems which occurred during the installation of the delineators. According to the resident, the work was accomplished by installing a few delineators at a time, whenever a break in other work occurred.

When asked about the application of the primer, the job foreman claimed that the delineators were mounted while the primer was tacky, not after it had completely dried per the manufacturer's instructions. He also said that no force was applied to the mount in order to effect the bond between the adhesive and the barrier. The foreman noted that the part of the bracket which interfaces with the barrier bowed when the nut was tightened. However, he stated that the butyl adhesive did not separate from the barrier at this time.

A problem was encountered with the stud installation. According to the people interviewed, at times the stud penetrated the barrier too deeply, or at an angle, hit a piece of aggregate and failed to go in, pulled out of

the barrier with or without a chunk of the barrier attached or rotated when an attempt to tighten the nut was made. Approximations of the frequency of an unusable stud installation varied. The inspector estimated a five percent occurrence, the contractor thought five percent was too high, and the job foreman claimed it occurred three out of five times.

The problems encountered in this initial inspection formed the basis for the major inspections performed after a year of weathering.

September and December 1978

A detailed inspection of 200 delineators was performed in both September and December 1978. The devices were inspected for any conditions which would presently or in the future, reduce the visual effectiveness of the installation such as failure of the attachment mechanisms, vandalism, damage to the components and improper installation techniques. A summary of the inspections is in Tables 1 and 2.

As can be seen in Table 1, the number of mounts exhibiting more than a slight amount of separation between the adhesive and barrier increased from 131 to 161 in the three months between inspections. The number of mounts with between half and all of the pad not adhering went from 41 to 50. Withincreasing exposure to the environment, the condition of the adhesive bonding is deteriorating. During this inspection, no evidence or residue from the application of a primer could be detected visually. It is thought that the apparent omission of primer and lack of force applied at the time of installation are responsible for the separation problems found. In the previous research study, during a comparable time of exposure and using the same materials, 44 percent

TABLE 1

INSPECTION OF MOUNTS AND ATTACHMENT MECHANISMS

	SEPTEMBER 1978 INSPECTION	DECEMBER 1978 INSPECTION
Number of Devices Inspected*	200	201
CONDITION OF BOND BETWEEN ADHESIVE AND BARRIER		
Slight Lifting of Butyl Pad (< 10%)	56	27
Moderate Lifting of Butyl Pad (10% - 50%)	90	111
Severe Lifting of Butyl Pad (> 50%)	29	40
No Adhesion of the Butyl Pad	12	10
Paper Not Removed From Butyl Adhesive	13	13
CONDITION OF CONCRETE STUDS		
Evidence of Failed Attempts to Shoot Stud Into Barrier	**	64
Stud Too Deep in Concrete - Device Installed Without a Washer	**	37***
Stud Not Fastened in Concrete - Device Missing or Pulls Out of Barrier	7	7
OTHER CONDITIONS FOUND		
Device Vandalized	2	7
Device Not Facing Traffic	4	4

*Although an attempt was made to inspect the same devices, some may not have been inspected both times, perhaps accounting for the decrease in the number of devices with no adhesion.

**Not investigated during this inspection.

***Twenty nine of these 37 devices exhibited either severe lifting of the butyl adhesive or no adhesion at all.

of the mounts had no lifting, while zero percent were found missing.[10]

In December, an inspection of the areas around the 201 studs yielded evidence of 64 failures to install a stud. This evidence took the form of small gouges in the top barrier surface, holes where the stud pulled out and the presence of unusable studs which were too deep in the concrete or at an excessive angle (see Figure 4).

Thirty seven of the mounts were installed without a washer since not enough of the threaded portion of the stud remained above the barrier top. Apparently the stud penetrated too deep in the concrete. Twenty nine of these 37 had severe lifting of the butyl adhesive or no adhesion at all. Of the 164 devices installed with washers, only 21 had such extreme lifting.

Vandals have apparently defaced several devices by cutting them with some implement, or attempting to pry the device off the barrier, or turning the mount so the reflectors did not face motorists. Whether any of the other damaged or missing reflectors were the products of vandalism is unknown (see Figure 5).

In addition to the suspected lack of primer usage and lack of washers, evidence of improper installation techniques was found on 17 devices. Thirteen delineators were installed without the paper being peeled off to expose the butyl adhesive, thus no bonding between the adhesive and barrier occurred. Four devices were apparently installed with the reflectors parallel to the motorists' line of sight. This positioning was not believed to be the result of vandalism since no residue of the adhesive was found in the normal position (see Figure 6).

A total of 26 reflectors were found damaged or missing in both the September and December inspections (see Table 2). How much of this damage was caused by vandals is not known but as previously stated, the loss of all eight reflectors on four closely spaced devices is thought to be vandalism.

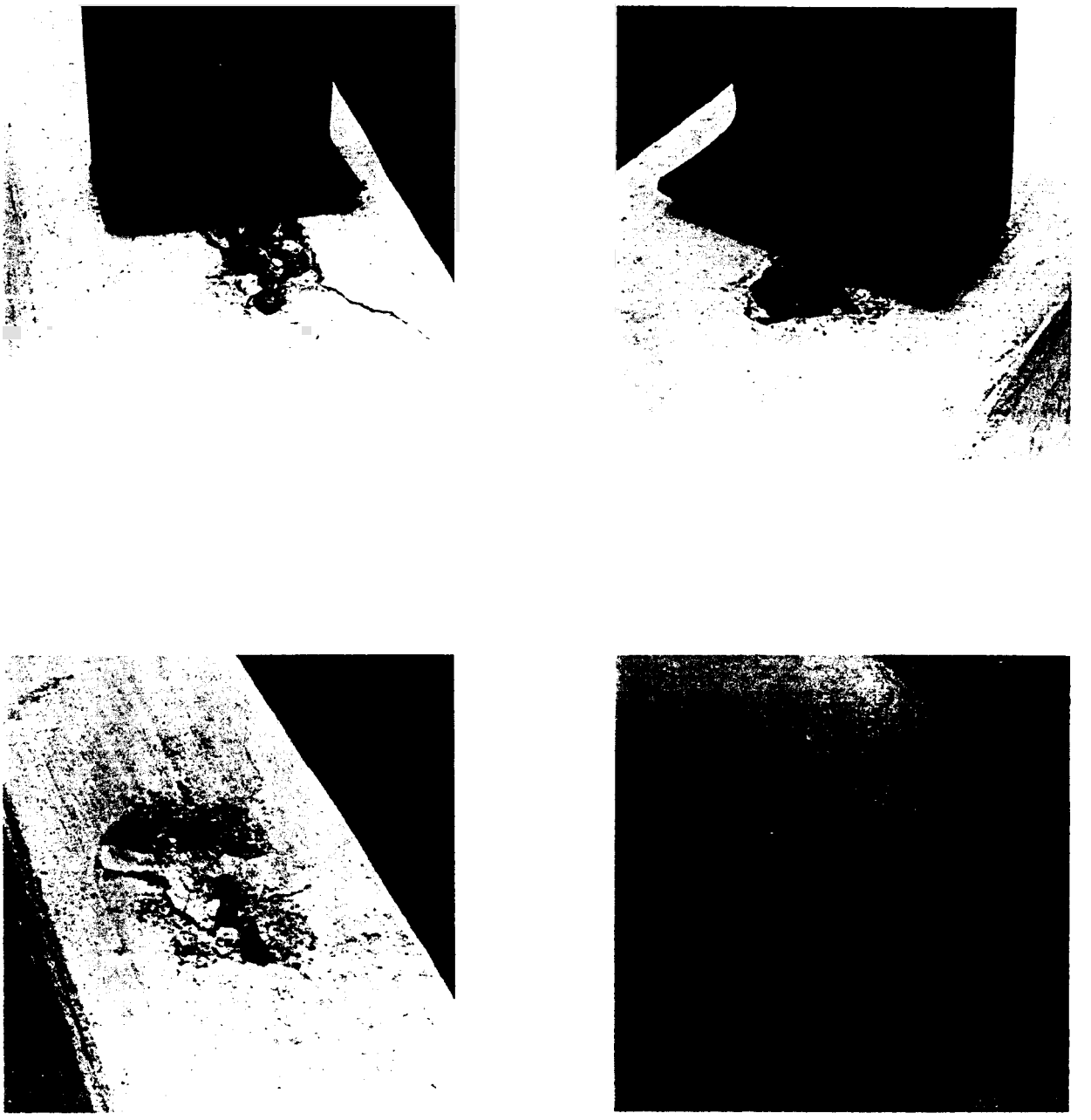
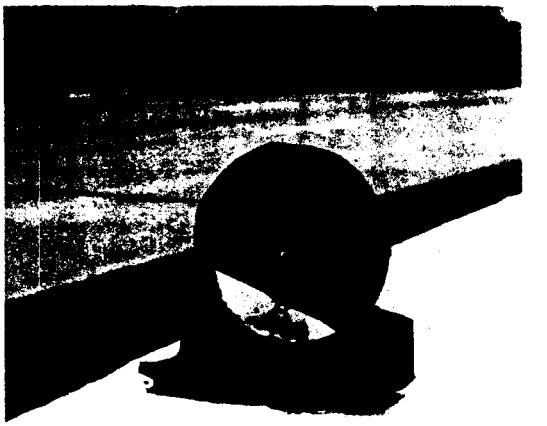


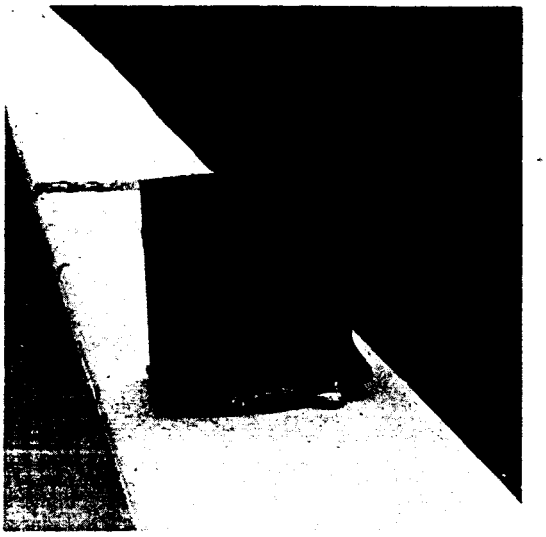
FIGURE 4

EXAMPLES OF UNUSABLE STUD INSTALLATION

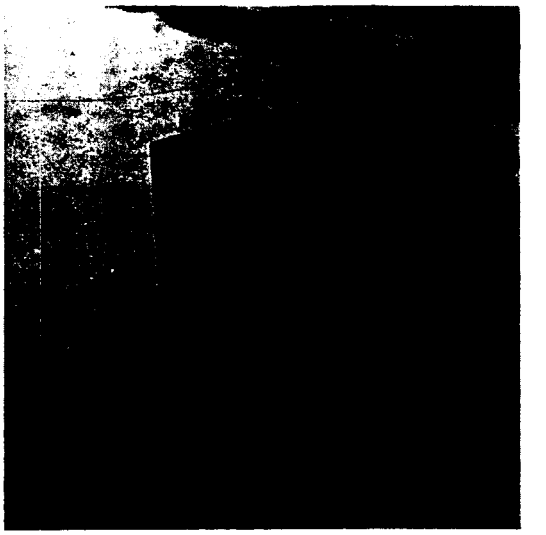
REFLECTORS MISSING
WOOD SCREW LEFT IN
PLACE OF BOLT



MOUNT CUT



REFLECTOR SPRAY PAINTED



ATTEMPT TO REMOVE
DEVICE FROM BARRIER

FIGURE 5

EXAMPLES OF VANDALISM

INSTALLED WITHOUT WASHER

PAPER NOT REMOVED
FROM ADHESIVE

INSTALLED PERPENDICULAR TO INTENDED POSITION
REFLECTORS NOT VISIBLE TO MOTORISTS

FIGURE 6

EXAMPLES OF IMPROPER INSTALLATION TECHNIQUES

TABLE 2

INSPECTION OF REFLECTORS

Condition of the Reflectors	September 1978 Inspection	December 1978 Inspection
Missing	17	17
Damaged	9	9

NIGHTTIME EVALUATION OF VISUAL EFFECTIVENESS

In September 1978, two engineers drove through the site at night under dry conditions and made the following observations:

1. On right-hand curves, the delineators showed up very well. It was estimated that as many as 20 devices (40 ft. spacing) could be viewed with low beams.
2. On left-hand curves, approximately three or four devices (40 ft. spacing) could be seen. View of downstream devices was blocked by the barrier itself unless the road was on an upgrade.
3. On tangents, approximately 15 devices (80 ft. spacing) could be seen.
4. In lit areas, the devices do not stand out due to the lack of contrast. They do not appear to provide any added delineation.
5. It was estimated that five lane lines (40 ft. spacing) could be viewed by the motorist during this inspection.

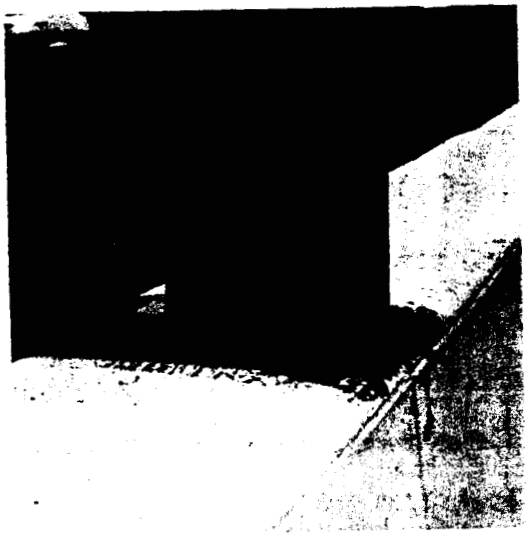
PILOT STUDY - MARCH 1979

In March 1979, a small scale pilot study was performed to see if a more complete and lasting bond between the adhesive and the barrier could be achieved. An aluminum plate, entirely covering the small face of the mount was substituted for the washer. It was believed that this plate would exert pressure over the whole adhesive pad, preventing separation from the concrete at the edges. The plates were cut from old signs of Alloy 6061-T6. Two thicknesses were used, 1/8" and 3/32". A total of four devices were installed, two with plates of each thickness (see Figure 7). A primer was used according to the job and manufacturer's specifications.

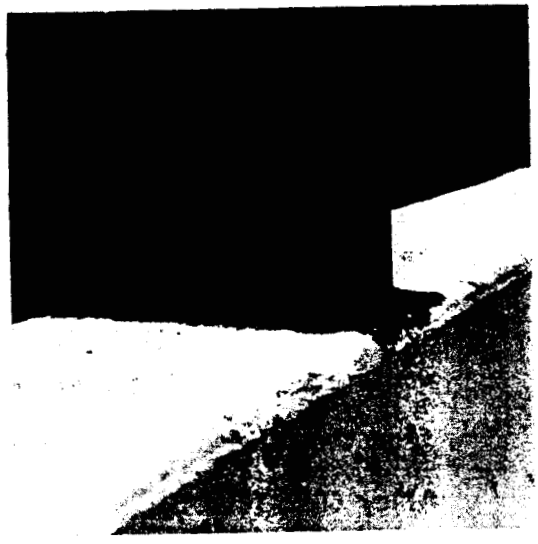
One mount with a 3/32" plate was pressed against the concrete to effect a bond before the plate and nut were added. The second device with a 3/32" plate was simply placed on the stud with the action of tightening the nut applying the only pressure on the adhesive. The nut was tightened on both devices until the plate just began to bend. Lifting of the adhesive from the concrete occurred at the edges of both devices.

The same procedure was used on mounts with 1/8" plates as with those having 3/32" plates. No separation occurred on either of the devices. Excessive tightening of the nut caused the stud to be lifted partly out of the barrier. However, the butyl adhesive still did not separate from the concrete, even at the edges.

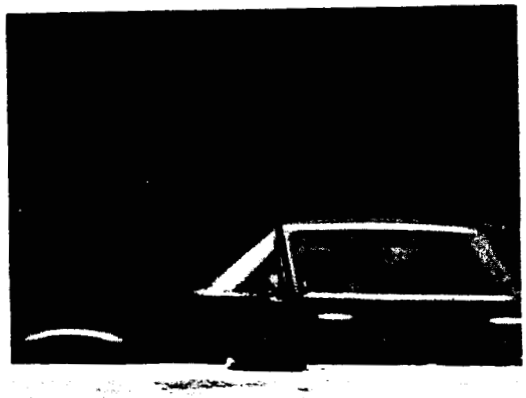
It was observed that by the time the nut had been tightened enough to bend the 1/8" plate, the large mount face had straightened and was at a 90° angle with the small face (see Figure 7).



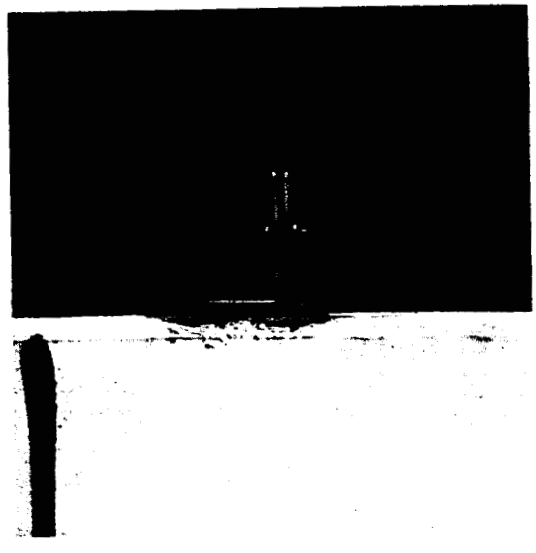
3/32" PLATE



1/8" PLATE



EXAMPLE OF BENDING
WHICH OCCURRED ON
ALL DEVICES



STRAIGHTENED BY
ADDITION OF PLATE

FIGURE 7

INSTALLATION OF DEVICES WITH
PLATES INSTEAD OF WASHERS

An inspection of the devices installed with the plates was made two months after their installation. There was no increase in the amount of the adhesive pad separated from the concrete for the devices with 3/32" plates and no separation at all for the devices with 1/8" plates.

RECOMMENDATIONS

Based on these inspections and studies, the following changes in the specifications for median barrier delineators are recommended:

1. Use Hilti stud W6-20-27 D12 instead of W6-20-22 D12 or equivalent. The shank length of the recommended stud is longer (27mm vs. 22mm). This change should increase the amount of the threaded portion of the stud available for use.
2. Replace the washer with a 1/8" aluminum plate. The plate will exert pressure over the entire smaller face of the mount which will improve the bond between the butyl adhesive and the concrete. It will also eliminate the bending of the bracket. The nut should be tightened until the plate just starts to bend.
3. Several reflectors may have been vandalized by removing the nut and bolt holding them to the mount. If such vandalism would be a problem, as in an urban area, vandal resistant nuts or a rivet could be substituted for the bolt. This will make vandalizing the devices and replacing them more difficult. In a previous research study, rivets were successfully used in this way.
4. The problems with an improper installation technique, including reflectors parallel to traffic and the failure to use a primer, can be overcome with more intensive inspection.

5. The use of delineators in well lit areas such as urban locations may not be useful in providing guidance to the motorist, but should be considered in case lighting is lost during adverse weather conditions. Interrupting the installation of the delineators at a lit interchange of an otherwise unlit road may pose more logistics problems than savings.
6. The use of Swareflex 329 might be considered for locations where long term brightness durability is desired over the higher costs for the initial installation.

REFERENCES

1. "Center Barrier Visibility Study," William L. Mullowney, New Jersey Department of Transportation, FHWA/NJ 80-002, January 1978, p. 25.
2. Mullowney, p. 27.
3. Mullowney, pp. 25-26.
4. Mullowney, p. 17.
5. Mullowney, p. 17.
6. Mullowney, p. 23.
7. Mullowney, p. 18.
8. Mullowney, p. 20.
9. Mullowney, p. 23.
10. Mullowney, p. 27.

APPENDIX

ADDENDUM NO. 3

BARRIER CURB DELINEATOR

Description

Barrier curb delineators shall consist of three inch amber reflectors mounted on a black ethylene vinyl acetate mount which is fastened to the top center of the concrete barrier curb.

Materials

Primer and Butyl Adhesive: The primer and butyl adhesive shall be compatible and shall be installed so that if the delineator mount is pulled away from the concrete barrier curb, separation will take place within the butyl adhesive material.

The primer for the butyl adhesive shall be as manufactured by the Minnesota Mining and Manufacturing Company, 5698 Rising Sun Avenue, Philadelphia, Pennsylvania 19120, or the Amerace Corporation, 7542 North Natchez Avenue, Niles, Illinois 60648, or the Intercoastal Corporation, Dundalk. P.O. Box 4060, Baltimore, Maryland 21222 or an approved equal.

The butyl adhesive shall be as manufactured by Spatz Paint Industries, Inc. 1601 North Broadway, St. Louis, Missouri 63102 or the Intercoastal Corporation, Dundalk, P.O. Box 4060, Baltimore, Maryland 21222 or an approved equal.

Mount: The mount shall be black ethylene vinyl acetate manufactured to the dimensions shown on the plan titled, Attachment No. 12 (see Figure 1).

Concrete Stud: The stud used to attach the mount to the concrete barrier curb shall be as manufactured by the Hilti Company, 1116 West Rockland Street, Philadelphia, Pennsylvania 19141, Catalog No. 3084528, Description W6-20-22 D12 or an approved equal. The stud is shown on the plan titled, Attachment No. 12. The stud shall be installed with a Hilti DX-400B Gun, Catalog No. 3/130 or an approved equal. The suggested power level index for the Hilti Gun is medium.

Reflector: The reflector shall be a three inch diameter amber reflector, Stimsonite No. 975, as manufactured by the Amerace Corporation, 7542 North Natchez Avenue, Niles, Illinois 60648 or Stratolite No. 75 as manufactured by the Miro-Flex Company, Inc., P.O. Box 514, Wichita, Kansas 67201 or an approved equal.

The bolt used to attach the reflectors to the mount shall be a 10-24 x 1" long slotted pan head stainless machine screw.

Methods of Construction

The delineator described hereinbefore is not available assembled. It shall be the contractor's responsibility to obtain the necessary parts and assemble the delineator.

Application of the butyl adhesive primer and butyl adhesive shall be in accordance with the manufacturer's recommendations.

Any damage caused to the concrete barrier curb as a result of installing the delineator shall be repaired by the contractor at his expense.

Care shall be exercised in tightening the bolt which connects the reflectors to the mount. Any damaged reflectors shall be replaced by the contractor at his expense.

Delineators shall be placed every 80 feet on tangents and every 40

feet on curves at locations indicated on the list titled, Attachment No. 13. Delineators with a single reflector shall be installed where specified on the list. The single reflector delineators shall be installed on the top center line of both sides of the split barrier curb and where barrier curb transitions into a wide median and there is no pavement adjacent to one side of the barrier curb.

Quantity and Payment

The quantity of barrier curb delineators for which payment will be made will be the number of delineators actually furnished in accordance with the plans, the specifications, and as directed by the engineer.

Payment for the item barrier curb delineators will be made for the quantity as above determined, at the unit price bid therefor in the proposal, which price shall include the cost of primer, adhesive, concrete studs, washers and nuts, bolts, reflectors, mount assembling and installing the delineators, all material, equipment, labor and all else necessary therefor and incidental thereto.

Delineators with a single reflector shall be measured and paid for under the item barrier curb delineators.