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Supplementary Notes				
Abstract This study investigated the feasibility of using fiberglass-reinforced plastic material as an alternative to aluminum for highway sign panels. An analysis of shop fabrication, installation procedures, field performance, reclamation, and cost was made for each material. It was concluded that the fiberglass reinforced-plastic material is an acceptable alternative to aluminum, and the Department should consider its use for highway sign panels on which to attach the reflectorized sheeting.				

FINAL REPORT
EVALUATION OF FIBERGLASS SIGN PANELS

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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INTRODUCTION

Signs on Virginia's highways require a substantial outlay of time and money for manufacture and maintenance. A major part of the cost goes for the sign panels on which the reflectorized sheeting is placed. It is necessary that the material used for sign panels provide an acceptable backing for the reflectorized sheeting in terms of adhesion and conformance and exhibit the field durability necessary to sustain the long life expected of the sheeting. Last year, Virginia used mostly aluminum for highway signs; almost \$1.5 million was spent for this material.

A possible alternative to aluminum is fiberglass-reinforced plastic (FRP). It has shown promise in tests in other states. Ohio concluded that FRP provides a viable alternative to aluminum as a substitute for flat sheet signs and allows the use of 0.135-in FRP for signs 36 in x 36 in or smaller. A study in Florida determined through laboratory and field evaluations that FRP panels are equivalent to aluminum panels and that the annual cost of the two materials was similar. It was recommended that 0.135-in and 0.075-in FRP be approved as a sign substrate material and be bid as an alternate to aluminum for equivalent 0.080-in and 0.040-in thicknesses.

Both Ohio and Florida felt that the inclusion of an alternate sign material was advantageous because of the price fluctuations in aluminum bid prices.

Based on information from the other states indicating that FRP is a viable alternative to aluminum as a substrate for sheeting, a study to investigate the use of FRP in Virginia was conducted.

PURPOSE AND SCOPE

Because of the potential advantages of the use of FRP instead of aluminum for highway signs, the feasibility of adopting this alternative was investigated by comparing the two materials.

Procedure

The fabrication of signs made with FRP--from handling and cutting the materials to attaching the reflectorized sheeting--was observed in Virginia.

The signs were installed in the field using the standard procedures used by the Department for erecting signs.

As a control, new signs with aluminum panels were installed in conjunction with the FRP sign panels. The signs were installed on the Route 29/250 Bypass around Charlottesville at five sites that will be described in a following section of this report.

Periodic field observations were made with emphasis on durability and compatibility with the reflectorized sheeting. For example, vandalism, crash damage, warpage, cracking, bubbles, wrinkles, etc. were noted.

An analysis of the costs of materials, fabrication, installation, reclamation, and maintenance was made as part of the evaluation.

EVALUATION

Sign Fabrication

The FRP material was ordered in specific panel sizes to correspond with selected signs which were to be replaced and/or refurbished. Because of the limitations in the panel sizes available, some larger sizes requested were unavailable; therefore, a combination of the smaller sizes was necessary to accommodate the larger sized signs. Since this study was done, FRP material has become available in larger sized panels up to 4 ft x 12 ft.

The FRP material was cleaned and cut to size with corners formed and holes drilled using available shop equipment. The only problem observed was some splintering, which may require the use of safety glasses and gloves when the material is being handled. Because the FRP is nonmetallic, chemical pre-treatment could be eliminated. The encapsulated lens sheeting was attached using a squeeze roll applicator. Copy and borders were direct-applied using the heat vacuum applicator. There was some question concerning the heating temperature and duration because of differences in the conductivity and retention of heat of the aluminum and FRP. Should FRP be used, specific instructions concerning the heat applicator temperature and duration should be available to ensure proper application of the encapsulated lens sheeting.

Overall, the fabrication of the sign panels in the shop posed no problems using the available standard equipment and normal procedures.

Field Installations

Test signs were installed on the Route 29/250 Bypass around Charlottesville. The specific sites and signs erected are described below. New aluminum signs were installed in conjunction with the FRP signs at some of the sites.

Site 1

Directional signs as shown in Figure 1 of Appendix A were installed with a new aluminum sign positioned on one side and FRP on the other. Figure 2 of Appendix A shows that the signs were mounted on vertical supports with signs attached at the mid-point using two bolts per sign. All signs ranged in size from 12 in x 24 in to 24 in x 24 in. The thickness of the aluminum and FRP was 0.080 in and 0.135 in, respectively.

Site 2

The 12-ft x 5-ft guide sign shown in Figure 3 of Appendix A, was fabricated using three 4-ft x 5-ft FRP panels. The original aluminum sign, which was one piece, was attached as shown in Figure 4 of Appendix A. The old aluminum sign was removed, and two horizontal sign supports were added to the original frame as shown in Appendix A, Figure 5. These additional members were necessary to ensure rigidity and alignment of the FRP panels. The FRP material was 0.135 in thick, and the replaced aluminum sign was 0.080 in thick.

Site 3

This site (see Appendix A, Figure 6) is similar to site 1. The directional signs contain aluminum and FRP materials positioned side by side.

Site 4

The 16-ft x 12-ft guide sign shown in Figure 7 of Appendix A was overlaid using six FRP panels that were attached directly over the original sign using rivets spaced at about 12-in centers. The FRP panels were 0.075 in thick.

Site 5

The old 12-ft x 5-ft sign at this site was replaced with a new FRP sign (see Appendix A, Figure 8). Three 0.135-in-thick panels were mounted using a Signfix support system, which involved attaching the panels to three metal horizontal supports as shown in Figure 9 of Appendix A.

Erection of all the FRP signs posed no problems, and the procedure was the same as with aluminum, except that extra sign support members had to be added to the FRP signs as noted earlier. The lighter weight of the FRP material made it easier to handle in the shop and field.

Also, because of the smaller FRP panels available, it took longer to overlay the sign at site 4 since more panels had to be used.

Durability

All signs were inspected periodically during a 2-year period. Durability was evaluated by observing any cracking, bubbling, and wrinkling of the signs. After 2 years, there was no noticeable deterioration of any of the FRP signs. Also, there was no difference in the FRP and aluminum signs relative to the durability of the reflective sheeting and backing material.

Legibility

Night inspections from a vehicle with lights on both high and low beam revealed no differences in legibility and retroreflectivity at sites 1 and 3 between the FRP- and aluminum-backed reflective sheeting. The FRP guide signs at sites 2 and 5 showed good legibility and retroreflective qualities during the observation period. The large guide sign at site 5 had some problems as a result of surface waviness. Figure 10 of Appendix A is a daytime photo of the signs revealing the unevenness of the overlay panels, which influences the sign legibility, especially at night. The nighttime legibility of this sign was good, and the waviness was not apparent, primarily because of the location of the sign and the angle at which the vehicle lights were striking it. Under different sign placement geometrics and surrounding lights (street, building, etc.), such surface waviness could be quite detrimental to nighttime legibility.

The cause of the waviness was the thin FRP overlay panels, which lacked the rigidity to lay flat when secured to the old sign using rivets.

Sign Reclamation

Signs that are taken down because of age, vandalism, deterioration, etc. are salvaged by reclaiming the usable portion and selling the remainder as scrap metal. Old signs (as shown in Appendix A, Figure 11) are reclaimed at the Department of Corrections in Halifax. Observations of the reclamation process for aluminum and FRP signs revealed the following.

Handling/Cutting

FRP signs are easily handled because of their lighter weight and ability to remain relatively cool during the sanding process. Cutting holes, forming corners, and shearing presented no problems using the equipment normally used for the aluminum. Also, it normally takes one person to straighten the aluminum around the bolt holes, whereas this is not required with the use of FRP.

Sanding

The sanding process for aluminum typically requires three to four passes for signs with encapsulated sheeting. FRP requires two to three passes. Figure 12 of Appendix A shows a FRP sign reclaimed after two passes through the

sander. Any potential problem relative to FRP dust created by the sanding process is alleviated by using wet sanding machines.

Costs

There was little difference between the costs of handling and fabricating signs made of either material. With the exception of the added supports on some large signs along with the extra time for overlaying, there was no difference in cost for sign installation.

Preliminary observations of the reclamation for each material revealed that there may be some advantages to the use of FRP since fewer passes through the sanding machine are required; it is lighter, stays cool, does not warp, and does not have to be straightened or flattened around bolt holes. There will, however, be more waste with FRP since unusable scrap cannot be sold as aluminum is. Presently, information with which to compare the cost of reclamation is unavailable, and only through further experience can this be determined.

It is believed that a cost analysis is best made through comparing the cost of new material with consideration given to purchase price, material salvage, and the expected life. This information can be used to predict the net present worth cost for each material. An example of this is given below using available cost and quantity figures from last year. The \$256,879 salvage value received last year from scrap aluminum (unrecyclable material) was used as a basis for estimating the expected yearly salvage values. Using an estimate obtained from three districts that approximately 75 percent of the signs replaced were vandalized/damaged and the remaining 25 percent were replaced when they reached the end of their service life, a yearly scrap aluminum salvage value of \$12,843 was used ($\$256,879 \times .75 = \$192,659/15 \text{ years} = \$12,843 \text{ per year}$). The amount reclaimable is assumed to be the same for both materials and is, therefore, not used in the analysis.

Assumptions:

- o 700,000 ft² of new material purchased
- o 15-year service life expectancy
- o \$12,843 per year salvage for aluminum
(\\$77,077 salvage after 15 years)
- o 0% per year salvage for FRP
- o \$2.07 per ft² cost of FRP
- o \$2.45 per ft² cost of aluminum

FRP: $700,000 \text{ ft}^2 \times \$2.07/\text{ft}^2 = \$1,449,000$
 No salvage value
 Net present worth = \$1,449,000

Aluminum: $700,000 \text{ ft}^2 \times \$2.45/\text{ft}^2 = \$1,715,000$
 $\$1,715,000 - \text{salvage value (1 to 14 years @ \$12,843/yr and 15th year of \$77,077)}$
 Net present worth = \$1,574,746

Using this analysis, the FRP material has a lower cost than aluminum by about 8 percent.

Should the Department decide to use FRP as an alternative material, it is recommended that detailed records of the field installations be kept for the purpose of obtaining information that can be used to more accurately estimate the costs. These records should include the location, number, and size of FRP signs (in addition to aluminum signs), along with replacement details relative to the signs replaced as a result of vandalism (stolen v. left in place), damage, and end-of-life replacement. Also, problems with fabrication, handling, and maintenance should be noted.

CONCLUSIONS

The following conclusions are based on the 2-year observation period for the test signs erected in the field and available information on material reclamation and cost.

- o Material preparation and sign fabrication in the shop were similar for both the aluminum and FRP materials.
- o The only difference in sign installation was the need to use extra supports for the larger signs (12 ft x 5 ft) and the extra time required to attach the overlay panels.
- o There was no observed difference in sign durability relative to the reflective sheeting and backing materials.
- o Legibility was observed to be the same for encapsulated sheeting placed on both materials; however, the overlaid sign had problems because of surface waviness caused by the unevenness of the FRP panels.
- o There were some advantages in the reclamation process for the FRP material because fewer passes through the sander were required and the material remained cool and did not warp. Aluminum, however, has a significant advantage since any unusable material can be sold as scrap. Only through experience and documentation of associated costs can the benefits of the reclamation process be properly investigated.
- o Based on the cost analysis, the FRP material was less expensive than aluminum. Price fluctuations and the percentages of reclaimable aluminum, however, will influence the cost differentials.

RECOMMENDATIONS

It is recommended that FRP be considered an acceptable alternative to aluminum for signs. Because of the extra supports required for the 5-ft x 12-ft signs and the problems associated with the overlaid signs, it is

recommended that sign size should be limited to 0.135 in thick and 30 in x 30 in. Experience with this size sign should be obtained prior to considering larger signs. Specifically, the cost, field performance, and reclamation process should be documented. A cost analysis using net percent worth may be used as a basis for comparing FRP and aluminum.

Should the VDOT decide to allow FRP as an alternative, additional information relative to installation and performance should be obtained as follows:

- o What is the largest .135-in FRP sign panel that can be attached to a single post?
- o At what FRP panel size are extra supports needed and, what would be the cost?
- o Are the larger .075-in FRP panel sizes now available suitable for overlaying?
- o Consideration should be given to using .135-in FRP for overlaying.

Appendix B gives Florida's specifications for 0.135 in FRP sign materials.

ACKNOWLEDGMENT

Appreciation is extended to the Culpeper District and Harry Carpenter for their help in fabricating and installing the signs. Also, Mark Alderman of the Maintenance Division is thanked for his help throughout this study.

APPENDIX A



Figure 1. Site 1 with aluminum and FRP panels.

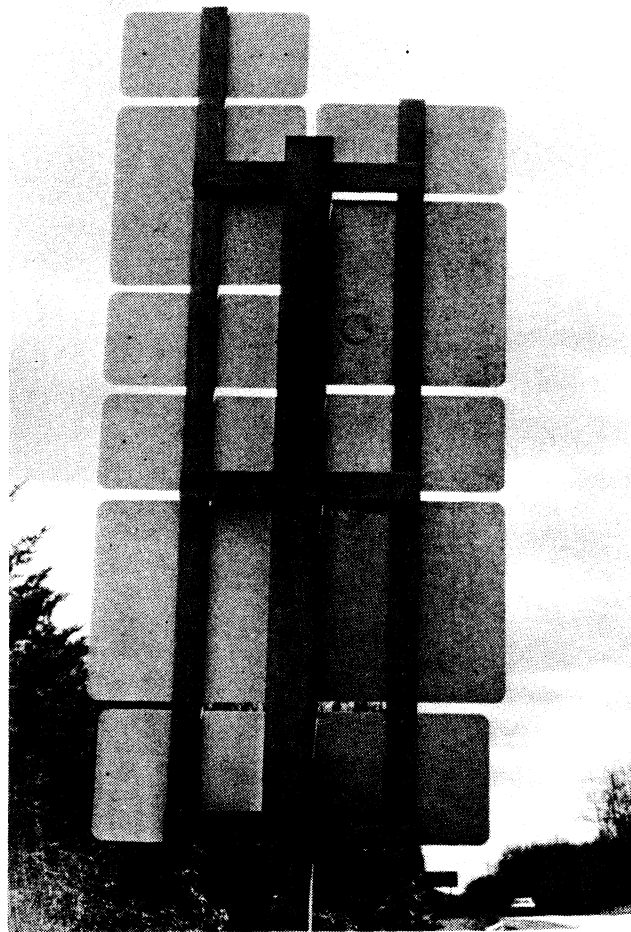


Figure 2. Sign support for site 1.



Figure 3. Site 2 using FRP panels.

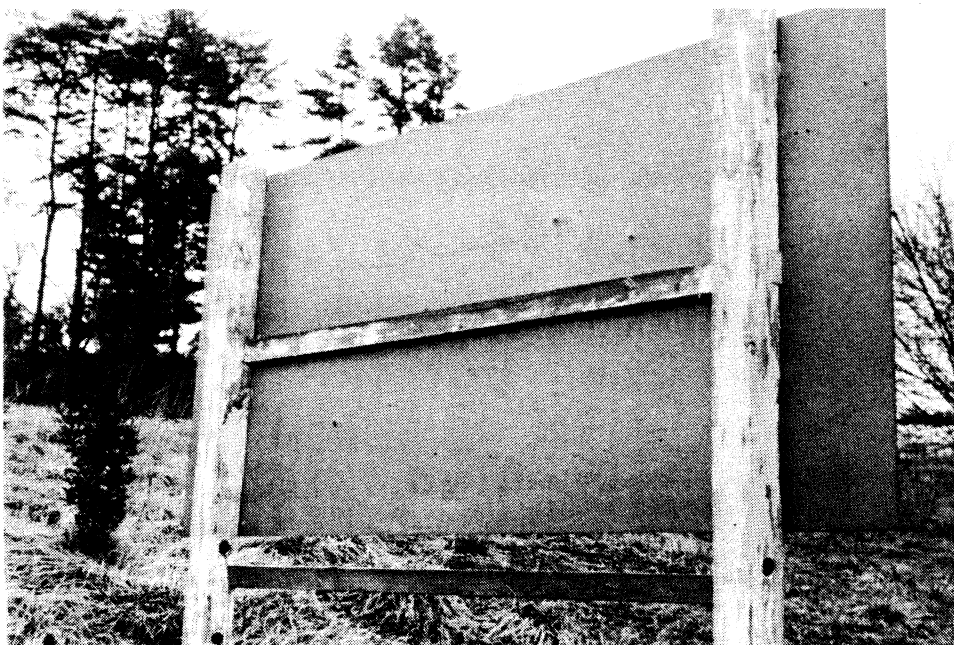


Figure 4. Original sign support at site 2 for old aluminum panels.



Figure 5. Extra sign supports attached at site 2 for new FRP panels.



Figure 6. Site 3 with aluminum and FRP panels.



Figure 7. Site 4 aluminum sign overlaid with FRP panels.



Figure 8. Site 5 using FRP panels.

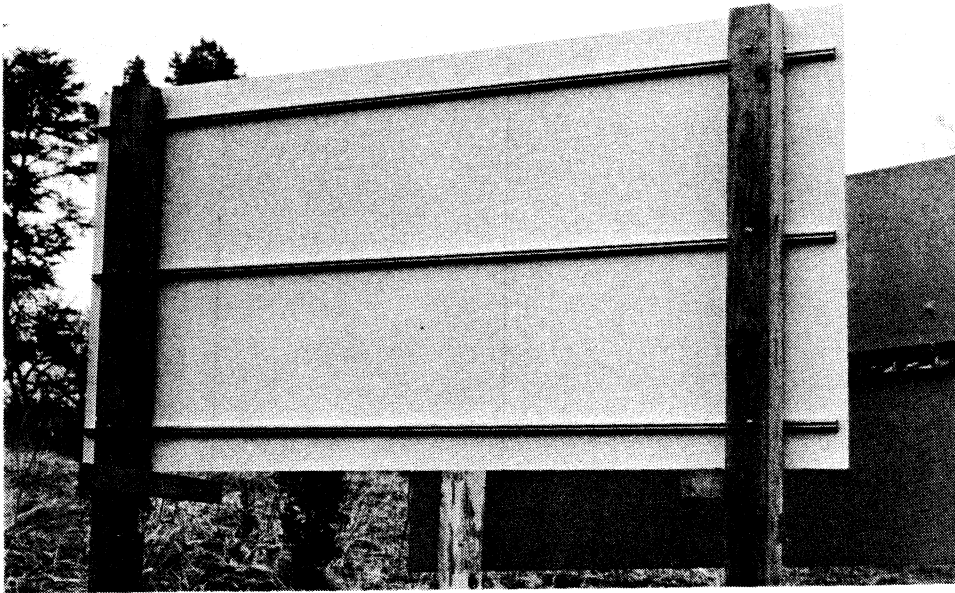


Figure 9. Sign support at site 5.



Figure 10. Unevenness of FRP overlay panel.



Figure 11. Aluminum sign panels prior to reclamation.

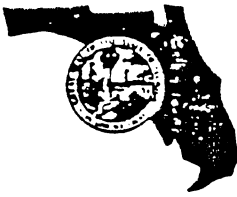


Figure 12. Reclaimed FRP panel.

APPENDIX B

Florida

BOB MARTINEZ
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1797
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KAYE M. HENDERSON
SECRETARY

FLORIDA DEPARTMENT OF TRANSPORTATION
SPECIFICATIONS FOR FRP SIGN MATERIALS

1. Sign Substrate Panels
(.135 mils)

FLORIDA DEPARTMENT OF TRANSPORTATION
SPECIFICATIONS FOR FIBER REINFORCED PLASTIC SIGN MATERIALS

I. General Laminate Properties

1. The FRP traffic control sign panel shall be a fiberglass reinforced thermoset polyester laminate. The panel shall be acrylic modified and uv stabilized for outdoor weatherability.
2. The panel shall be stabilized so as not to release migrating constituents (i.e. solvents, monomers, etc.) over time and shall contain no residue release agents on the surface of the laminate that will interfere with any subsequent bonding operations.
3. The panel shall not contain visual cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel or otherwise affect its serviceability.

III. Physical Properties

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- 3.1 Panel Thickness -- .135 inches (tolerance \pm .005 inches)
- 3.2 Panel Width and Length -- tolerance to \pm 1/8 inch per 12 foot length or less when measured in accordance with ASTM D3841-80.
- 3.3 Panel Squareness -- tolerance to \pm 1/8 inch per 12 foot of length when measured in accordance with ASTM D3841-80.
- 3.4 Smoothness -- Panels shall be manufactured with smooth surfaces on both the top and bottom of the panel.
- 3.5 Pigmented to a visually uniform gray color within the Munsell^R range of N.7.5/ to N.8.5/.
- 3.6 Coefficient of Thermal Expansion --- a maximum of 1.8×10^{-5} in/in/°F.
- 3.7 Weatherability -- The panel shall be classified as to a minimum Grade II (weather resistant) panel as specified in ASTM 3841-80 following a 3,000 \pm 100 hour weatherometer test.
- 3.8 Fire Resistance -- The extent of burning shall not exceed 1.0 inches when tested in accordance with ASTM, Method D635-81.
- 3.9 Panel Flatness -- This test requires five 30-by 30- inch FRP panels. Initial warpage is measured in four directions: 0°, 45°, 90°, and 135°. To measure warpage, the panel is freely suspended at one corner, and a straight edge is placed along the panel so that the edges of the panel touch the straight edge. Care must be exercised so as not to disturb the dimensional characteristics of the panel. A rule graduated in fractional inches is used to measure the distance from the center of the panel face to the straight edge. That distance is measured to the nearest 1/32 inch in all four directions.

The panels are then freely suspended diagonally in an oven for 48 hours at 180°F. After 48 hours in the oven, the panels are removed and allowed to cool to room temperature freely suspended. Warpage measurements and corresponding direction are again recorded as described above.
- 3.10 Impact Resistance -- Using the 1.18 pound falling ball test in accordance with ASTM D3841-80, the panel shall resist an impact of the ball dropped at 60 feet.
- 3.11 Thermal Stability -- Strength and impact resistance qualities shall not be appreciably affected over a temperature range of - 65°F to 212°F.

IV. Applicable Documents

4.1 ASTM Standards:

- D3841-80 Glass Fiber Reinforced Polyester Panels, Specifications for
- D638-80 Tensile Properties of Plastics, Test for
- D790-80 Flexural Properties of Plastics and Electrical Insulating Materials, Test for
- D695-80 Compressive Properties of Rigid Plastics, Test for
- D635-81 Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position, Test for
- D732-78 Shear Strength of Plastics for Punch Tool, Test for
- D696-79 Coefficient of Linear Thermal Expansion of Plastics, Test for

4.2 Specified Standards:

Panel Flatness Test

V. Material Acceptance

- 5.1 The producer shall furnish six (6) certified copies of the mill analysis covering each shipment of each size and type of material to:

Engineer of Materials, Research & Testing
Department of Transportation,
Post Office Box 1029
Gainesville, Florida 32601

At the option of the Department the material may be accepted on the basis of the producers certified mill analysis or from results of tests made on a random sample selected from the shipment after delivery.

Time Limit of Delivery: Delivery of this material at the Point of Destination shall be within 90 days from the receipt of the order.