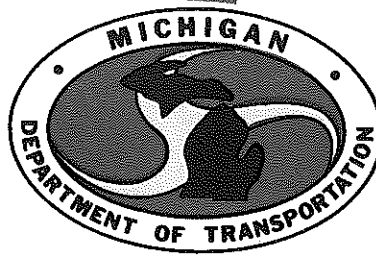


EVALUATION OF SILANE TREATED GLASS
BEADS IN POLYESTER PAVEMENT
MARKING PAINT



MATERIALS and TECHNOLOGY DIVISION



TE203 .B37 1986 c. 2
Evaluation of silane
treated glass beads in
polyester pavement marking
paint

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EVALUATION OF SILANE TREATED GLASS
BEADS IN POLYESTER PAVEMENT
MARKING PAINT

F. J. Bashore
A. W. Price

A Category 2 Project Conducted in
Cooperation with the U. S. Department
of Transportation, Federal Highway Administration

Research Laboratory Section
Materials and Technology Division
Research Project 83 G-260
Research Report No. R-1269

Michigan Transportation Commission
William C. Marshall, Chairman;
Rodger D. Young, Vice-Chairman;
Hannes Meyers, Jr., Carl V. Pellonpaa,
Shirley E. Zeller, William J. Beckham, Jr.
James P. Pitz, Director
Lansing, February 1986

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INTRODUCTION

The retention of glass beads in the surface of pavement marking materials is necessary for effective nighttime delineation. Since the bond between glass and polyester is very poor, it was thought that the use of a silane coupling agent to establish a chemical bond might help maintain a greater number of beads in the surface.

The first field trial of silane treated beads was conducted in 1982 in conjunction with performance testing of polyester pavement marking paints. A series of transverse stripes were applied using Potters Industries CP-01 silane treated glass beads. Specifications for the rate of bead application in contracts required 15 lb/gal of polyester paint. Since the bead gun system on the test striper was incapable of applying this quantity, the test stripe beads were hand applied in a sufficient quantity to cover the surface resulting in a somewhat higher rate. These stripes were consistently higher in retro-reflectance than control stripes using untreated beads of the same Michigan gradation.

Because of these favorable test results, it was decided that silane treated beads should be tried on a project to be done under contract. A work plan was prepared, submitted to the FHWA, and approved. An addendum was issued to Construction Project FUG 84900-20776A, etc., changing the specification for the beads. Copies of the Work Plan, specifications, and the addendum are provided in the Appendix.

Two other contracts were let at the same time; one specifying untreated beads and the other specifying a 50-50 blend of untreated and flotation type beads. The latter was tried because a Michigan contractor reported using the blend on county and city projects with what he believed to be superior results. The beads on all three contracts were to comply with AASHTO Specification M247, Type I.

All three contracts were awarded to Clark Highway Services of Lake City, Michigan and the polyester selected by the contractor was a product of the Baltimore Paint and Chemical Co. The areas covered by the contracts were urban areas where effective delineation had been difficult to maintain over the winter months with Michigan's standard hot-applied fast dry pavement marking materials. Traffic volume maps were used to select roadways utilizing the three bead types with as nearly equivalent traffic volumes as possible. Traffic volumes for the roadways selected ranged from 9,000 to 15,000 ADT and consisted of five areas for standard beads, five areas for silane beads, and four areas for 50 percent flotation beads.

One area from each group was ultimately deleted because of severe wear caused by local conditions permitting tracking of sand and gravel onto the roadways. In addition, a second silane bead area was deleted because severe scraper damage left little material to be evaluated.

The three contracts were completed between July 15, 1983, and August 1, 1983. Evaluation, using the Department's retro-reflectometer began November 10, 1983. Ratings with the retro-reflectometer were taken at approximate three-month intervals through August 15, 1984.

It was obvious with the first set of data that the silane coated beads were not performing as expected and gave reflectances lower than the standard beads and much lower than the 50 percent flotation mix. Examination of chips taken from the projects showed that the silane coated beads were almost entirely submerged in the polyester with very little of the beads exposed. Average retro-reflectances for the three bead types are shown in Table 1. The retro-reflectometer readings had been previously compared to ratings by observers. An instrument reading of 1.5 on white paint was determined to be equivalent to an ASTM D713 rating of 4.

TABLE 1
RETRO-REFLECTANCE OF POLYESTER PAVEMENT
MARKINGS USING DIFFERENT BEAD TYPES

Service Time, Days	Bead Type		
	Silane Coated	Standard	50% Flotation- 50% Standard
73			3.6
77		3.2	
88	2.17		
184			2.6
185		1.9	
200	1.58		
266			3.1
268		2.6	
284	2.36		
376		2.4	3.1
391	2.05		

To confirm the field test results, panels were prepared in the laboratory and measurements were made with the retro-reflectometer. The white polyester was catalyzed, applied to glass panels with a drawdown blade to a thickness of 15 mils, and bead loadings of 15 to 22.5 lb/gal were added. These measurements are shown in Table 2.

It should be noted that the wide ranges shown for some of the panels are a result of uneven distribution using a salt shaker with a weighed amount of beads applied by hand. However, the laboratory test results do tend to confirm the field test results.

Table 2 indicates that optimum retro-reflectance is obtained with

standard beads at a level above 20 pounds per gallon. It is also indicated that equivalent retro-reflectance is obtained with the 50 percent flotation - 50 percent standard mix at a bead loading of only 15 lb/gal.

TABLE 2
RETRO-REFLECTOMETER MEASUREMENTS OF
LABORATORY PREPARED PANELS OF WHITE
POLYESTER WITH VARIOUS BEAD LOADINGS

Bead Loading, lb/gal	Bead Type		
	Standard	Silane	50% Flotation-50% Standard
15	3.7 - 5.0	2.0 - 2.9	5.0 - 5.6
17.5	3.5 - 4.5	2.3 - 2.6	5.0 - 5.8
20	4.6 - 5.6	3.0 - 4.4	6.0 - 7.0
22.5	5.9 - 6.2	4.3 - 4.8	

The coupling effect between the silane coating and the polyester was demonstrated by the fact that the polyester with silane coated beads started peeling from the glass panels within 24 hours while the other panels required soaking in water overnight to break the bond between the paint and the panel. Polyesters tend to shrink slightly upon curing and the chemical bond between the silane coating and the polyester apparently increased the shrinkage enough to quickly cause the bond between the polyester and the glass to fail.

Visual examination of chips from the field indicated that scrapers used for snow and ice removal sheared many beads off at the surface of the polyester (all three types of beads) indicating that the mechanical locking of beads submerged at least to their midpoints, is sufficient. Beads submerged a lesser amount are not thought to contribute to retro-reflectance significantly. It can be concluded that the coupling agent of the silane coated beads is not necessary because the strength and rigidity of the polyester effectively holds the well embedded and effective beads mechanically.

Conclusions

- 1) The use of silane coated beads did not exhibit any improvement for the bead loading and gradation specified.
- 2) The bead loading for the standard bead was lower than optimum and was increased from 15 to 18 lb/gal for the 1984 contracts in Michigan.
- 3) The 50 percent flotation - 50 percent standard bead mix gave the best retro-reflectances and was specified at the 18 lb/gal rate for the 1985 Michigan contracts.

4) Silane treatment is not necessary because polyester paints hold beads adequately.

Suggested Items for Future Experiments by Others

It is not intended that the Research Laboratory pursue this work further, due to the author's retirement, and other higher priority work. However, the following factors are suggested for those who may wish to conduct additional experiments in the future.

1) The bead gradation generally used with polyester is AASHTO M247, Type I, which permits from 5 to 25 percent of the beads to be retained on a No. 30 sieve (0.0232 in.). The ultimate thickness of a 15 mil polyester line loaded with beads is about 20 mils or 0.020 in. Perhaps a somewhat larger gradation would be effective at bead loadings of less than 20 lb/gal.

2) Only one mix of flotation and standard beads was tried. Other mix ratios as well as other gradations and bead loadings may be more cost effective.

3) Most contractors use compressed air guns to place beads on the paint stripe. Air from the bead guns combined with varying natural wind conditions prevent deposition of all beads on the paint line resulting in waste of a significant portion of the beads. Development of a mechanical delivery system with a shrouded delivery area could result in more efficient bead usage.

APPENDIX

**EVALUATION OF SILANE TREATED GLASS BEADS
IN POLYESTER PAVEMENT MARKING PAINT**

**Research Laboratory Section
Testing and Research Division
Research Project 83 G-260
Work Plan No. 90**

**Michigan Transportation Commission
William C. Marshall, Chairman;
Rodger D. Young, Vice-Chairman;
Hannes Meyers, Jr., Carl V. Pellonpaa,
Shirley E. Zeller, William J. Beckham, Jr.
James P. Pitz, Director
Lansing, May 1983**

The Problem

Glass beads are applied to wet pavement marking materials to provide retro-reflectance for night visibility. The beads are bonded to the paint surface mostly by mechanical locking of the beads into the surface. Beads that are not embedded at least to their midpoint are anchored poorly and are easily removed by traffic.

Silanes bond well to glass and act as coupling agents to various organic materials. Silane treated beads have been used as fillers for plastics giving significant increases in strength compared to non-treated glass beads.

The 1982 series of polyester pavement marking performance tests included a set of stripes reflectorized with silane treated beads. While these tests have not been finalized, retro-reflectance test results have been consistently higher than the controls using non-treated beads.

Scope

Potters Industries, Inc., CP-01 silane treated beads have been specified on Construction Project FUG 84900-20776A, etc., which covers various urban areas in Districts 4 and 5. Adjacent contracts in Districts 6 and 7 using non-silane treated beads will be used for comparison.

Objective

The objective of this project is to evaluate the effectiveness of the silane bead treatment in maintaining better night visibility of polyester traffic paint.

Benefits

The retention of better retro-reflectance would increase the effectiveness of delineation for the safety of the public. An increase in longevity would be of direct monetary benefit to the Department if it is enough to give an extra season of service.

Status of Known Research

Several states including Oregon and New Mexico have used silane treated beads on alkyd type paints although we are not aware of published reports of research leading up to this usage. Some usage of silane treated beads with polyester paints has been reported but documentation is lacking.

Construction Procedure

Application of the silane treated beads will be at the rate of 15 lb/gal of paint and is detailed in the project proposal.

Evaluation

The performance of the silane coated beads will be evaluated by periodic measurements made with the Department's retro-reflectometer. Adjacent contracts using non-silane coated beads will be used as controls. Measurements will be made at three-month intervals on selected sites in experimental and control projects.

Project Supervision

The Research Laboratory of the Testing and Research Division will be responsible for evaluation and reporting. F. J. Bashore, Supervisor of the Coatings, Sealers, and Plastics Group will be the Project Leader. The Construction Division will be responsible for construction supervision in the usual manner.

Personnel, Space, and Facility Requirements

No special provisions will be required.

Material Costs

The silane treated beads cost approximately 1-1/2 cents per pound more than standard beads. It is estimated that the additional cost, based on estimated quantities in the project proposal, will be about \$330.

Time Requirements

Performance trends should become evident within two years. An initial report will be issued after the first year. It is expected that four years may be required for final conclusions.

Estimate of Research Costs

	<u>1983-84</u>	<u>1984-85</u>	<u>1985-86</u>	<u>1986-87</u>
Salaries and Wages	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500
51.19 Additive Cost	1,280	1,280	1,280	1,280
Travel and Subsistence	425	425	425	425
Reports	200	100	100	400
Incidental Costs	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
Totals	\$ 4,505	\$ 4,405	\$ 4,405	\$ 4,705
TOTAL Cost of Project	\$18,020			

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SUPPLEMENTAL SPECIFICATIONS
FOR
POLYESTER PAVEMENT MARKINGS
(Beads: 100% Nonflotation)

DESCRIPTION:

This work shall consist of furnishing and applying polyester pavement marking materials in accordance with the lines and dimensions shown on the plans, or as described herein. The contractor shall furnish all material, labor, and equipment necessary for the required pavement preparation and marking application, protection of the work, and traffic control.

All markings shall conform with the requirements of the Michigan Manual of Uniform Traffic Control Devices for Streets and Highways.

Marking materials shall conform to applicable portions of the following specifications. The materials shall be reflectorized.

LINE TYPES:

Pavement markings shall consist of lines of 4-inch or 8-inch widths. Lines shall be white or yellow, continuous, broken, or dotted as directed by the Engineer.

MATERIALS:

Polyester pavement markings shall be standard highway white or yellow as specified.

Marking material containers or packaging shall be plainly marked with an indication of the material color. Containers shall also be marked with an identification number of the production batch or lot of the material.

Material supplied under this specification shall be a two-component polyester system capable of being applied by conventional truck-mounted spray equipment at ambient temperature. Material shall be capable of retaining reflective glass spheres of the "drop-on" type.

The polyester marking material shall be selected by the contractor from a list of approved proprietary products which may be obtained from the Testing and Research Division, telephone number (517) 322-1632, extension 28. The contractor shall obtain the the supplier's recommendations for handling and application of products to be furnished for the work, and submit copies to the Project Engineer before work is started.

The catalytic component of the system shall be any commercially available type recommended by the manufacturer of the polyester.

The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a "no tracking" condition in 30 minutes or less. The pavement surface temperature shall be 55°F or higher at the time of application. Faster dry times can be expected at higher temperatures but dry time of less than three minutes shall be avoided to provide better adhesion to the pavement.

Glass beads used with polyester pavement marking shall be in accordance with AASHTO Specification M247, Type 1.

Glass beads stored on project sites shall be protected against moisture absorption to prevent becoming wet or caked. Bead containers shall be plainly marked for identification of bead type.

EQUIPMENT:

The pavement marking equipment shall be equipped with a pressure regulated air jet capable of removing all debris from the pavement in advance of the applicator gun. The air jet shall be operated only as needed or as directed by the Engineer.

The contractor shall use an accurate dashing mechanism, capable of being easily adjusted, to retrace existing lane or center line markings as specified in the plans or as directed by the Engineer.

All vehicles used in marking operation in traffic shall be equipped with rotating or oscillating flashers which are visible from both the front and rear of the vehicle and an Illuminated Target Arrow, Type B, capable of being visible from either the front or rear of the vehicle.

The trailing vehicle shall be equipped with an appropriate sign visible from the rear indicating the following legend:

"Pavement Marking Ahead"

The trailing vehicle shall also be equipped with an Illuminated Target Arrow, Type B, which shall be visible from the rear.

Provisions for the described special equipment by the contractor shall be incidental to the application.

CERTIFICATION OF COMPLIANCE:

The contractor shall furnish a certification that the material and application equipment complies with the requirements of this specification. It shall not be inferred that the providing of a certification of compliance waives inspection, sampling, or testing. The contractor shall furnish samples of the beads and polyester materials, if required by the Engineer.

SURFACE PREPARATION AND MARKING APPLICATION:

The contractor shall be responsible for cleaning and preparing the

pavement, to the satisfaction of the engineer, such that at the time of markings application the pavement shall be free of dirt, dust, oil, grease, concrete curing material or other contaminants. A power broom shall be used when directed. The pavement shall be dry and have a surface temperature of 55°F or higher before marking application is applied. When directed by the Engineer, a jet of compressed air shall be used to remove debris immediately prior to material application.

New bituminous wearing surface shall be in place for a period of not less than four weeks prior to application of polyester pavement markings.

Lines shall be applied as solid, broken, or dotted lines, either singly or in combination, as directed by the Engineer. Broken lines shall be applied in a 50-foot cycle consisting of a 12½-foot segment and a 37½-foot gap between segments. Dotted lines shall be applied in a 25-foot cycle consisting of a 5-foot segment and a 20-foot gap between segments.

The contractor shall transfer the entire contents of each material container to the striper tanks. Polyester marking material as received from the manufacturer shall be applied uniformly to the surface to be marked. The material shall be thoroughly mixed at all times during application. Thinning shall not be permitted. When applied, the polyester material shall dry to a no-tracking condition in 30 minutes or less.

The material shall be applied at the following rate to provide a uniform wet film thickness of 15 mils ± 10 percent:

- Solid 4-inch line - 16 gallons per mile of line.
- Solid 8-inch line - 8 gallons per mile of line.
- Broken 4-inch line - 4 gallons per mile of line.
- Dotted 4-inch line - 3 gallons per mile of line.

Glass beads shall be applied to the wet polyester marking material so that the beads are uniformly embedded and retained in the material and uniformly cover the surface of the marking material to the point where there are loose beads on the surface of the wet line. The rate of application shall not be less than 15 pounds of glass beads per gallon of marking material applied.

The contractor shall furnish personnel who are experienced in the work of application of polyester pavement marking material.

Applied markings shall be sharp, well defined, provide uniform retro-reflectivity, be free of uneven edges, overspray, or other readily visible defects which, in the opinion of the Engineer, detract from the appearance or function of the pavement markings. The width of line applied shall be the width specified plus or minus ½ inch.

Markings which are improperly located shall be corrected. Improperly located markings shall be removed at the contractor's expense, in a manner acceptable to the Engineer; and reapplied in the correct locations at the contractor's expense.

Markings which are applied with material shortages exceeding six percent of the specified rates shall be properly reapplied at the contractor's expense or be subject to acceptance with applied deductions as provided in Deductions for Material Deficiencies.

Applied markings with defects such as, but not limited to, fuzzy edges, nonuniform thickness, improper width, non or nonuniform retro-reflective features, or an adhesion failure with the pavement surface, shall be considered unacceptable.

Unacceptable markings shall be corrected as provided in Final Acceptance.

METHOD OF MEASUREMENT:

The length of lines paid for shall be the number of lineal feet of marking material of the color and type specified; gaps between marked segments are not included in the measurement.

The quantity of polyester marking material or glass beads applied per unit of measurement will be computed by the Engineer at the end of each day's work.

A day's applied mileage of less than 10 miles of edge lines, center lines, lane lines, or channelizing lines may be included in the next day's applied markings for the purpose of computing marking materials and bead application rates.

The contractor shall cooperate with the Engineer in providing measurements whenever requested. The marking application rate shall be determined by dividing the total gallons used by the appropriate marking length as determined by the Engineer. Any determination of pay deduction resulting from shortages in marking quantities shall be based on the measurements obtained by this method. The glass bead application rate shall be determined by dividing the total pounds used by the total gallons of polyester used.

The contractor shall provide a calibrated measuring device to measure the polyester resin in the striper tanks.

DEDUCTION FOR MATERIAL DEFICIENCIES:

A daily tolerance of six percent for material shortages shall be permissible without deductions. Any determination of pay deduction resulting from shortages in marking materials or glass beads shall be based on the measurements obtained under Method of Measurement.

If the six percent tolerance has been exceeded on material shortages, the markings shall be reapplied at the contractor's expense or the contract unit price will be reduced in direct proportion to the greatest deficiency up to a maximum of 20 percent.

If the deficiency of any material is more than 20 percent, the day's work shall be considered unsatisfactory and shall be reapplied at full expense to the contractor, including all labor, equipment, and material requirements.

BASIS OF PAYMENT:

The pay items for this project are white polyester pavement marking; yellow polyester pavement marking, of the widths and types specified. Cleaning of the road surface, protecting the work area and traffic control, shall be incidental to the project.

Payment for accepted quantities complete in place will be made at contract unit prices, or prices adjusted in accordance with Deduction for Material Deficiencies. Payment shall be full compensation for all materials, labor, incidentals, and equipment necessary for placement of the polyester marking material.

FINAL ACCEPTANCE:

Final acceptance of approved completed markings shall be 30 days after completion of all original work to assure the marking's durability.

If lineal feet of unacceptable pavement markings exceed five percent of the total applied markings under the contract, the unacceptable markings shall be reapplied with markings conforming to these specifications and requirements to the extent determined by the Engineer, at the contractor's expense, without delay.

2-22-83

NA(115T-435)-4

Reflective Systems Unit

NOTICE TO BIDDERS
LETTING OF MAY 5, 1983

ADDENDUM NO. 1

Item No. 8305 003 Project FUG 84900-20776A Fed No. FG 000S(123)
MUG 84900-20777A MG 000S(124)
RSG 61073-20778A RSG 6109(201)

Prospective bidders on the above noted project are hereby advised that on Page 44 of the proposal in the title delete Beads 100% Nonflotation and insert (Beads: 100% Silane Treated).

On Page 45 of the proposal delete the second paragraph and replace with the following:

Glass beads used with polyester pavement marking shall be silane treated CP.01 manufactured by Potters Industries, Inc. and shall be in accordance with AASHTO Specification M247, Type 1.

James P. Pitz, Director
Michigan Department of Transportation

Lansing, Michigan
4-26-83
nkm