FINAL REPORT

EVALUATION OF YELLOW-WHITE PAINT MIXTURES

by

Frank D. Shepard
Research Scientist

(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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PREFACE

This study was initiated by Deputy Commissioner and Chief Engineer Leo E. Busser III on the basis of a Federal Highway Administration (FHWA) report suggesting that a substantial savings could be realized through the substitution of diluted yellow-white paint for the standard yellow used by the Department and other agencies. A task force composed of W. C. Nelson, Jr., of the Traffic and Safety Division as chairman, and Norman E. Hood of the Fredericksburg District, J. E. Galloway, Jr. of the Materials Division, and Frank D. Shepard of the Research Council was formed to evaluate the FHWA suggestion and develop recommendations. The study was a joint effort of the members of the task force.

This report was prepared by the Research Council.

SUMMARY

In view of the potential cost savings to be achieved through the use of the regular yellow traffic paint diluted with less expensive white paint, it was decided that the Department would evaluate roadway applications of the paint mixture with emphasis on the compatibility of the Department's painting equipment and procedures with the proposed paint mixture, the motorist's reactions to the diluted yellow color, and the cost savings by using the mixture. Conclusions and recommendations are presented based on the evaluation of two test sections in the Fredericksburg District.

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INTRODUCTION

The Manual on Uniform Traffic Control Devices (MUTCD) requires that white lines be used to delineate the separation of traffic flows in the same direction or mark the right edge of the pavement, and that yellow lines be used to delineate the separation of traffic flows in opposing directions or mark the left edge of the pavement of divided highways and one-way roads. These requirements have prompted considerable debate concerning the relative visibilities of white and yellow pavement markings, especially at night and under adverse lighting and weather conditions. The Federal Highway Administration (FHWA) recently funded an investigation of the driver's visibility requirements for roadway delineation with emphasis on determining the least proportion of yellow highway paint needed in a yellow-white paint mixture for the mixture to be identifiable as being yellow. The study concluded that the yellow highway paint now used may be diluted up to 50% with white paint without loss of color identity for driving conditions under which color is normally visible. As noted in the report on the investigation, the replacement of some of the yellow pigment with white pigment could be advantageous since yellow paint lines are initially less reflective than white ones, and they darken considerably with exposure after painting. Also, because of their lower brightness contrast with the pavement, yellow markings are typically not as visible as white under adverse driving conditions of night lighting, rain, fog, and windshield degradation. From an economic standpoint, the investigation indicated that a substantial cost savings could be realized by diluting yellow paint with white paint to a 50:50 pigment weight ratio.

In view of the potential cost savings to be achieved through the use of the diluted yellow paint, it was decided that the Department would evaluate roadway applications of the paint mixtures specified in the FHWA report.

PURPOSE AND SCOPE

The purpose of this study was to investigate the use of yellow-white paint mixtures for highway delineations with particular emphasis on the following:

(a) the compatibility of the Department's painting equipment and procedures with the proposed paint mixture,

(b) motorists' reactions to the diluted yellow color, and

(c) the cost savings that could be realized by using the mixture.

The evaluation was limited to comparisons of the regular yellow and diluted yellow paints used for centerlines and edgelines on 2-lane bituminous and concrete highways.

PROCEDURE

Test Sections

Two test sections in the Fredericksburg District were selected for the application of the yellow-white paint mixtures. One was a 14-mile section of Route 2 (2-lane, bituminous) between New Post and Bowling Green; the other included the Route 360 bridge (2-lane concrete) crossing the Rappahannock River at Tappahannock. It is noted that both test sections were on rural highways with no artificial lighting except vehicle lights.

The regular yellow paint was taken from the stock and the mixture contained 2 gal. of white paint and 1 gal. of yellow paint (50:50 weight pigment ratio). The paints were applied to the roadway in the following manner.

1. Where there were two adjacent lines, such as a skip line next to a solid line or a double solid line, the left line was painted with the diluted paint and the right line was painted with regular yellow.

2. Where there was only a single skip line, diluted paint was used.

3. To minimize the influence of the application equipment on adjacent lines, the paint was switched half way through the test section; i.e., on the last half of the section the diluted paint was applied on the right and the regular paint was applied on the left. The bead guns were not switched. This permitted observation of both paint stripes with the same bead application.

4. The paints were applied using normal procedures; i.e., the rate was approximately 6 lb./gal. of beads on a paint film (dry) thickness of 13 to 14 mils.

The entire process was carefully monitored to determine the compatibility of the equipment and procedures with the diluted paint mixture and to note any problems encountered.

Evaluation of Color

The relative yellowness of the stripes of diluted paint was evaluated by comparing it to that of lines made with the standard yellow paint. Comparisons were made through the use of a questionnaire given to Department personnel. The questionnaire was filled out on two occasions and included ratings of the stripes under both daylight and darkness.

RESULTS

Application Process

With reference to Mr. Hood's memorandum included in the Appendix, the mixture of 2 gal. of white paint to 1 gal. of yellow paint was ideally suited for application with the painting equipment used in the Fredericksburg District. The capacity of the paint tanks on the equipment is 165 gal. Achieving the proper ratio was simply a matter of placing two barrels of white paint and one barrel of yellow paint in the tank.

Pumping a barrel of white, a barrel of yellow, and then the second barrel of white into the tank resulted in a good mixing action, as noted by Mr. Hood. After the tank was filled, the mechanical agitators were turned on. By the time the equipment reached the section of roadway to be striped, the paint was thoroughly mixed and ready for application. In summary, Mr. Hood offered the following observations.

1. The mixing of the paint poses no problem. It requires no great change in loading procedures and there is no added expense.

2. Use of the mixture will require close scheduling by the supervisor, because all of the paint in the tanks must be used up before a new batch can be mixed. To obtain the 2 barrels to 1 ratio, the full capacity of the tank must be used.

Questionnaire Survey

Thirteen questionnaires were filled out by Department personnel — five upon the installation of the stripes and eight approximately nine months afterwards. The questionnaire is shown in Table 1 along with percentages of responses to the questions.

Table 1

Percentages of Responses to the Survey Questionnaire
New Post and Tappahannock

	Day			Night		
	Yes	No	Little	Yes	No	Little
1. Can you detect differences between the yellow and the diluted yellow lines? (Route 2, Bituminous)						
a — double solid	90	0	10	27	27	46
b — broken (passing — one direction)	80	0	20	27	27	46
c — broken (passing — both directions)	67	11	22	20	30	50
2. Can you detect differences between the yellow and diluted yellow lines? (Rappahannock Bridge, Concrete)						
a — double solid	90	0	10	64	9	27
3. In your opinion is the diluted yellow line sufficiently yellow to be distinguishable from white lines?	100	0	0	91	0	9
4. Is the diluted yellow line more visible than the regular yellow?						
a — close-up	44	33	23	36	36	28
b — faraway	56	22	22	55	27	18

5. Your general opinion concerning the use of diluted yellow paint for centerline marking from the standpoint of color (yellowness) and visibility (brightness and distance).

Following are comments on the results.

1. Can you detect differences between the yellow and the diluted yellow lines? (Route 2, Bituminous)

   a — Double solid: A large percentage (90%) of the respondents perceived a difference between the paints during daylight. At night, however, as many did not detect a difference (27%) as did (27%), and 46% saw little difference.

   b — Broken (passing — one direction): Eighty percent noted a difference while 20% noted a minimal difference during daylight. At night, the percentages were the same as for the double solid marking; that is, 27% noted a difference, 27% did not, and 46% noted little difference.

   c — Broken (passing — both directions): During daylight 67% said they saw a difference, 11% did not see a difference, and 22% saw a minimal difference. During darkness, a slightly higher percentage noted no difference, 30% vs. 20%, while 50% saw little difference.

   Many respondents commented that, although it was difficult to detect a difference in the color, the diluted paint appeared to be a shade lighter.

2. Can you detect differences in the yellow and the diluted yellow lines? (Rappahannock Bridge, Concrete)

   a — Double solid — Ninety percent noted a difference during the day, while at night 64% noted a difference, and another 27% noted a slight difference.

   Some respondents opined that while there was a difference in shade, both lines were yellow. Also, some noted that it was not as easy to detect a difference at night as it was in the daylight.

3. In your opinion is the diluted yellow line sufficiently yellow to be distinguishable from white lines?

   Everyone thought there was a difference during the day, while 91% could distinguish a difference at night. Nine percent saw no difference at a glance; however, these evaluators could detect a difference upon observation.

4. Is the diluted yellow line more visible than the regular yellow?

   a — Close-up: Forty-four percent thought the diluted yellow was the more visible during daylight, 33% did not, and 23% noted a minimal difference. At night, opinions were evenly divided; 36% thought the diluted yellow line more visible, and an equal percentage thought it was not.

   b — Faraway: Under daylight 56% thought the diluted lines to be more visible, 22% saw no difference, and 22% saw a minimal difference. At night, 55% thought the diluted paint was the more visible, 27% did not, and 18% thought there was little difference.

5. Your general opinion concerning the use of diluted yellow paint for centerline marking from the standpoint of color (yellowness) and visibility (brightness and distance).

   The comments can be summarized as follows:

   — Difficult to tell differences between colors in the sun.
   — Diluted paint is yellower and brighter.
   — Diluted is more visible in wet weather.
   — One color is as good as the other.
   — Diluted could be used.
   — Minimal difference in lines.
   — Little difference at night; more difference in day; however, daylight not as critical.
   — Diluted should be acceptable as a substitute for regular yellow.
   — When bead application rate is equal, the diluted yellow shows fine.
   — Diluted yellow will work.

It is noted that on one occasion six observers viewed the test section on bituminous pavement during wet conditions at night. It was the general consensus that the heavier the rain, and therefore the greater the film of water on the lines, the more difficult it was to observe any difference between the colors of the pavement markings.

Figures 1 through 5 are photographs of the diluted and standar paints on the test sections.

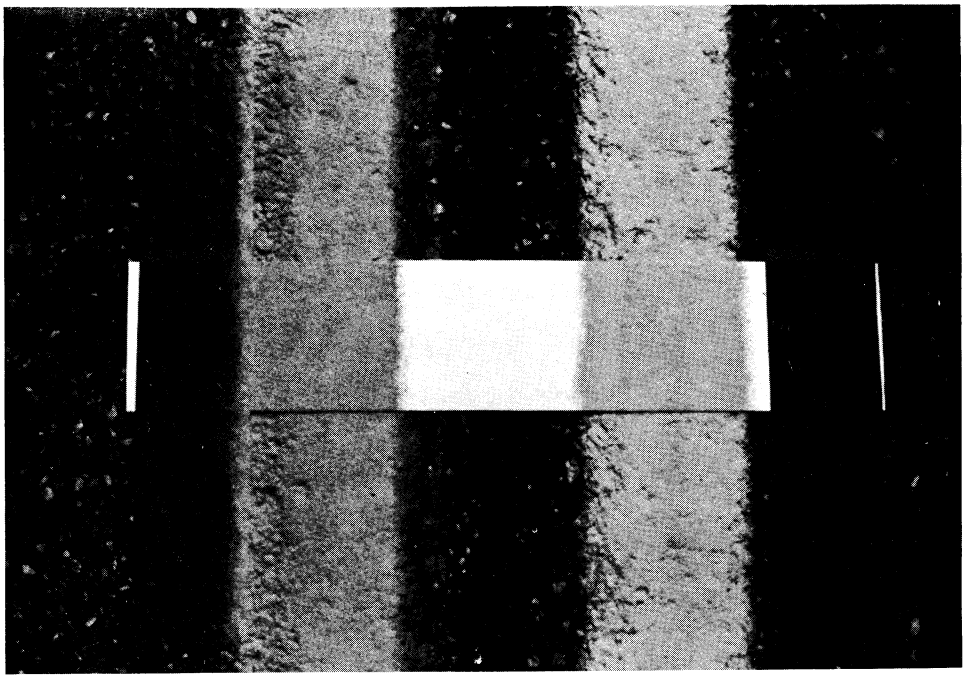

Figure 1. Close-up of test plates showing regular yellow, on left, and diluted yellow.

Figure 2. Double solid line on bituminous pavement. Regular yellow on left.

Figure 3. Passing, one direction, on bituminous pavement.

Figure 4. Double solid line on bituminous pavement at night.

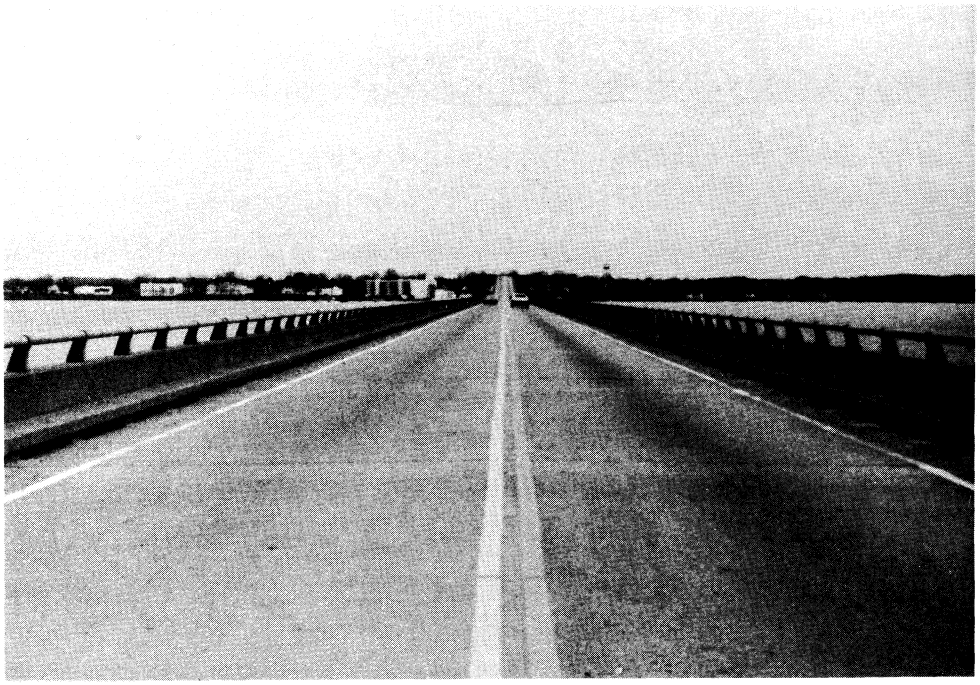

Figure 5. Double solid line on concrete pavement. Regular yellow on right.

Cost Savings

An estimate of the cost savings realizable through using diluted yellow paint was made by taking the amount of yellow paint used in the state last year and projecting a cost based on present paint prices.

Present Total Annual Cost

Yellow paint used annually	284,000 gal.
White paint used annually	340,000 gal.
Cost — yellow paint	$4.60/gal.
Cost — white paint	$4.05/gal.
Total cost/yr. yellow - 248,000 gal. x $4.60 =	$1,306,400
Total cost/yr. white - 340,000 gal. x $4.05 =	$1,377,000
Total cost of paint	$2,683,400

Projected Cost Using Diluted Yellow

2/3 x 284,000 gal. = 189,332 gal.
1/3 x 284,000 gal. = 94,667 gal.

Amount white normally used:	340,000 gal.
Amount white replacing yellow (diluted):	189,332 gal.
	529,332 gal.
Amount yellow used after dilution	94,667 gal.
Cost white = 529,332 gal. x $4.05/gal. =	$2,143,795
Cost yellow = 94,667 gal. x $4.60/gal. =	435,468
Total cost paint using diluted	$2,579,263

Cost before dilution	$2,683,400
Cost after dilution	$2,579,263
Yearly savings using diluted	$ 104,137

Cost Savings

Savings on all paint (white and yellow) = $\frac{\$\ 104,137}{\$2,683,400}$ = 3.9%

Savings on yellow paint:

Cost yellow —		$1,306,400
Cost white —	equal amount	$1,150,200
Extra cost —	yellow	$ 156,200

Total cost of diluted	$2,579,263
Cost if all white, 624 gal. x $4.05/gal.	$2,527,200
Extra cost when using diluted	$ 52,063

Extra cost yellow	—	$156,200
Extra cost using diluted	—	$ 52,063
Savings using diluted	—	$104,137

Percentage of the extra cost of using standard yellow can be saved using diluted yellow: 104,137/156,200 = 67%.

It is, therefore, estimated that an annual cost savings of $104,137 can be realized if diluted yellow were substituted for the regular yellow. This figure reflects a savings of 3.9% of the total cost of all paint used and a 67% savings of the extra cost of using yellow.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, the application of the diluted paint with existing equipment and procedures presents no problems. The mixing and loading procedures presented no problem and there was no added expense. It is noted, however, that using diluted yellow paint with the present equipment will require close scheduling by the supervisor to ensure that all the paint in the tanks is used before a new batch can be mixed properly.

The two questionnaire surveys revealed that differences in the shade of yellow could be detected during the day, but that it was difficult to detect differences at night. Also, it was found that the diluted yellow line was sufficiently yellow to be distinguishable from white lines. Opinions were mixed on the ability to detect differences in visibility, both close-up and faraway. Overall, the surveys revealed that although differences were noted in the relative degrees of yellowness of the standard yellow and diluted yellow, the diluted was still yellow, the differences in shades of yellow were minimal, and the diluted should be acceptable as a substitute.

Preliminary cost estimates indicate a substantial savings in the cost of paint should the Department change to diluted yellow. Approximately 3.9% of the total cost of all paint used and 67% of the extra cost of using the standard yellow could be saved using diluted yellow.

It is recommended that if permission can be received from the FHWA for the placement of diluted yellow instead of the regular yellow, the diluted paint should be tried in the entire Fredericksburg District to gain more knowledge of the advantages and any disadvantages of using it before considering application on a statewide basis.

APPENDIX

1499 Form No. 22-A

DEPARTMENT OF HIGHWAYS

INTER-DEPARTMENTAL MEMORANDUM

TO :

Fredericksburg , Virginia

FROM : Mr. Norman E. Hood

July 10, , 19 80

SUBJECT: A Report On The Use of Diluted Yellow Traffic Zone Paint In The Fredericksburg District

Route_____ Proj._____

In recent months interest has been generated in the use of diluted yellow traffic zone paint. This interest centers on honest attempts by managers to make the tax dollar do a more efficient job. With the cost of everything escalating so rapidly, it is vitally necessary that this be done.

In order to determine if a savings could be effected by the use of this diluted paint, it was decided to make a test application in the Fredericksburg District. It had to be proven that the dilution of the paint would not significantly alter the performance of the material.

Two sections of roadway were selected for this performance evaluation. One was a stretch of Route 2 between New Post and Bowling Green. This section of Route 2 is approximately 14 miles long and is in Caroline and Spotsylvania Counties.

The mixture decided upon was a 2 to 1 ratio; i.e., two gallons of white paint to one gallon of yellow paint. This ratio was ideally suited to the painting equipment presently being used in the Fredericksburg District. The capacity of the paint tanks on the existing equipment is 165 gallons. Achieving the proper ratio was simply a matter of putting 2 barrels of white paint and 1 barrel of yellow paint in the tank.

The paint was pumped into the tank in the sequence of a barrel of white, the barrel of yellow, and then the second barrel of white. This method resulted in a good mixing action. After the tank-filling operation was completed, the mechanical agitators were turned on. By the time the equipment reached the section of roadway to be painted, the paint was thoroughly mixed and ready for application.

The paint was applied to the roadway in the following manner:

1. Where there were two adjacent lines, such as a skip line next to a solid line or a double solid line, the left line was painted with the diluted paint and the right line was painted with regular traffic zone yellow.

2. Where there was only a single skip line, it was painted with the diluted paint.

3. In order to assure proper evaluation of bead distribution and retention, approximately half way through the test section, the paint was switched, i.e., the diluted paint was put on the right side and the regular paint was put on the left side. The bead guns were not switched. This procedure permitted evaluation of both kinds of paint with identical bead application.

4. Samples of each paint and method of application were obtained by placing aluminum strips in the roadway in the path to be painted. These samples were retained for laboratory evaluation.

5. Since the application, several inspections, during both night and day, have been made of the two test areas with the following results:

   a. The diluted paint is readily recognizable as yellow paint.

   b. There is no apparent excess spalling of beads from the diluted paint. In my last inspection of the test areas, July 2, 1980, the bead retention of the diluted paint was equal to the bead retention capability of the undiluted paint.

As a result of my participation in this evaluation, I offer the following:

1. The mixing of the paint poses no problem. It requires no great change in loading procedures. There is no added expense.

2. Use of the diluted paint will require close scheduling by the supervisor in that the paint truck must be completely "painted out", or all of the paint in the tanks must be used up, before a new batch can be mixed, because to obtain the proper 2 to 1 ratio, the full capacity of the tank must be used.

3. It is my recommendation that the Fredericksburg District be permitted to run a pilot program and use the diluted paint district-wide for a period of one year. With proper record keeping, this should allow proper evaluation of the cost savings that might result from its use.

NEH/gf