EFFECTS OF ROTATION ON THE NIGHTTIME BRIGHTNESS OF OVERHEAD HIGHWAY SIGNS UTILIZING HIGH INTENSITY SHEETING

by

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SUMMARY

As an initial step in the establishment of guidelines for the use of high intensity sheeting on overhead signs, a pilot study was made to investigate the effect of rotation on the average nighttime brightness of signs utilizing this material. Rotation angles were chosen on the theory that the brightness will be maximum when the entrance angle is minimum.

The study concluded that while the theory used was generally correct, rotation did not significantly improve the average night brightness on the special overhead signs evaluated.

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INTRODUCTION AND PROBLEM

At the present time, the Virginia Highway and Transportation Research Council is engaged in a study of the feasibility of using high intensity (encapsulated lens) sheeting on overhead highway signs.(1) The preliminary results of the study, scheduled for publication in December 1974, have indicated that for selected situations the use of high intensity sheeting may be recommended as a replacement for the presently used enclosed lens material.

The economic benefits of high intensity sheeting are significant. The standard enclosed lens sheeting currently used requires external illumination, which entails the expense of the initial light installation and the ever rising costs of power and maintenance. It is hoped that encapsulated lens sheeting, which does not need exterior lighting, can be substituted for the enclosed lens material and thus provide considerable financial savings for the state.

During the early data collection phases of the high intensity sheeting evaluation project, it was observed that the brightness of signs located on roadways having a curved approach was considerably lower than the brightness of signs at sites having a straight approach. Many of the brightness readings became unacceptably low as the distance from the sign increased. This lack of uniformity suggested that the approach was responsible for this effect. The immediate ramification of this phenomenon was that if high intensity sheeting was to be utilized on overhead highway signs in the state of Virginia, guidelines would have to be formulated for that use.

However, the problem was not merely one of determining if the road geometry affects the brightness of overhead highway signs using high intensity sheeting, this has been the subject of at least one previous study.(2) Also involved was an examination of possible means of minimizing or even eliminating the effect, so that the range of situations under which the proposed material might be utilized could be maximized.

OBJECTIVE AND SCOPE

The objective of this study was to investigate the effect of rotation on the nighttime brightness of overhead highway signs utilizing high intensity sheeting and to make observations concerning the possible use of this technique on the state highways.

Due to manpower, financial, and time constraints, the scope of this project was limited to one study site.

STUDY SITE

The site selected for study was the overhead sign located on the exit ramp leading from the westbound lanes of Interstate Route 66 to Route 123 in Fairfax County as shown in Figure 1. This site was selected because the three-degree curve was considered a desirable maximum degree of curvature for arterial and interstate roads according to Virginia's Road Designs and Standards.(3)

The exit ramp selected for study is a two-lane facility containing a three-degree horizontal right curve and grade of 1.80%. The maximum safe speed limit on this road is 45 miles per hour (2.0115 m/s). There is a limited visibility distance, approximately 900 feet (274.32 m), due to geometry and topography.

STUDY PROCEDURE

In this study the technique of sign rotation was examined for the purpose of seeking the maximum brightness of non-illuminated overhead signs on roads containing approaches with horizontal curves. In determining a method of sign rotation, the range of possible entrance angles (incidence angles) encountered by a motorist approaching one of these signs was minimized. In general, the entrance angle, as illustrated in Figure 2, is defined as that angle formed by a light ray striking a surface at some point and a line perpendicular to the surface at the same point.(4) For the purposes of this report, the entrance angle was considered that angle subtended by the centerline of an approaching car, a point at the geometric center of the sign, and a line perpendicular to the sign at that point.

The first step in the data collection phase was the taking of luminance readings at the selected site. The before data, taken in conjunction with the aforementioned high intensity evaluation study, were taken of the non-illuminated high intensity sign at several distances and from both the left and right lanes. All readings were taken with a Gamma Scientific, Inc. Model 2009 Auto-Telephotometer and recorded in foot-lambert units. This particular instrument has a range of 10^{-5} to 10^{6} foot-lamberts (3.426×10^{-5} to 3.426×10^{6} cd/m^2) and the photometric measurement accuracy is within 4% of full-scale.

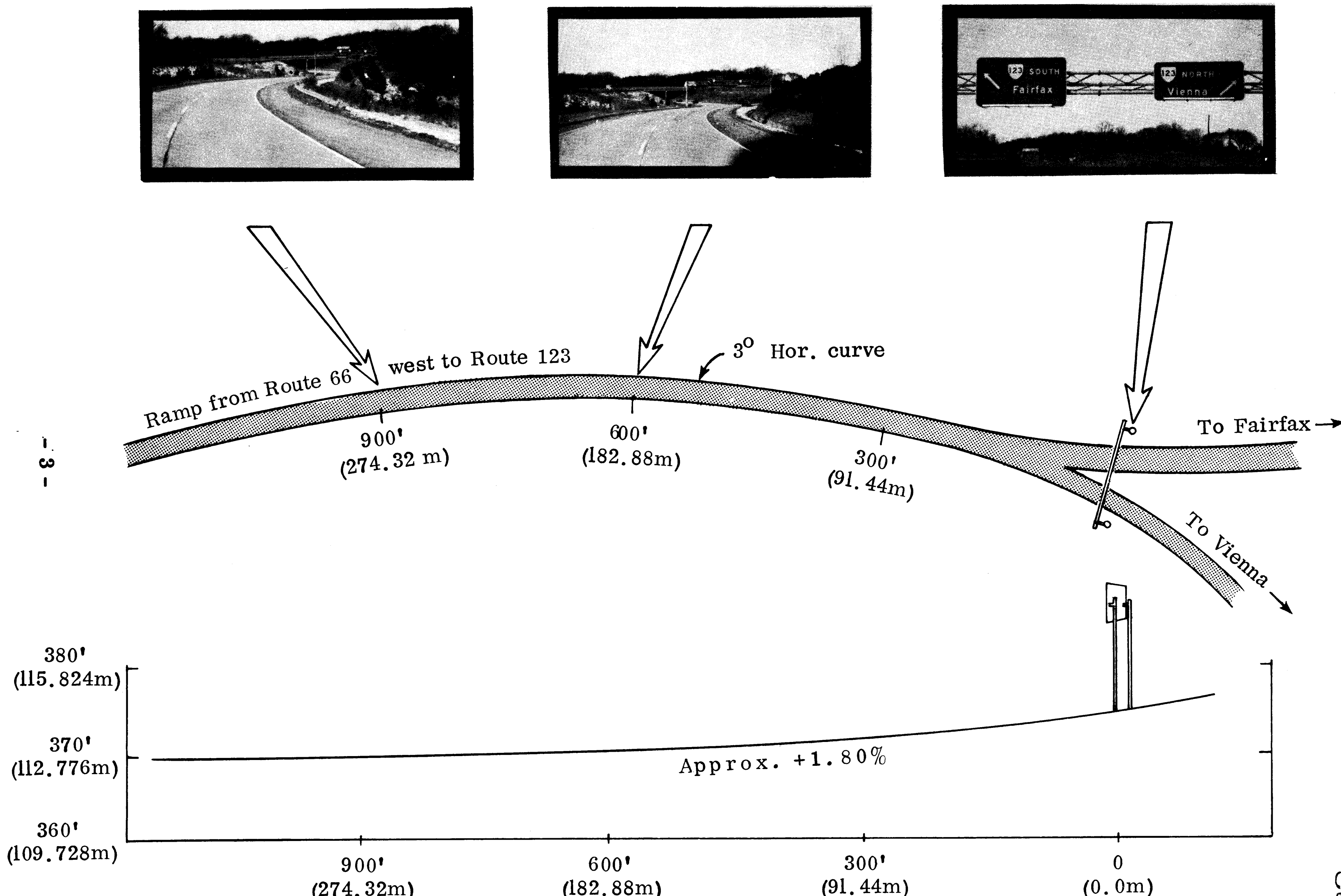

Figure 1. Study site — ramp from Route 66 west to Route 123, Fairfax County.

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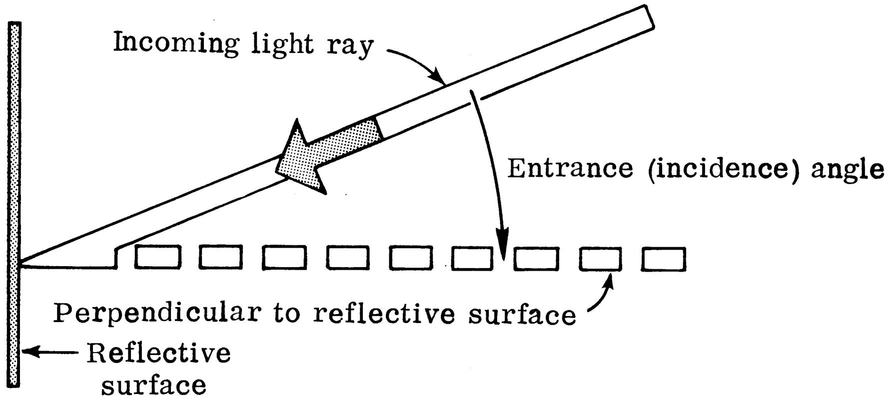

Figure 2. Entrance angle.

The second phase of the data collection consisted of mounting a special sign covered with the high intensity material. The sign shown in Figure 3 had dimensions of 30" x 30" (.762 m x .762 m) and was divided into four squares, two silver and two green. This color scheme represented both the background and legend materials found on overhead guide signs in Virginia.

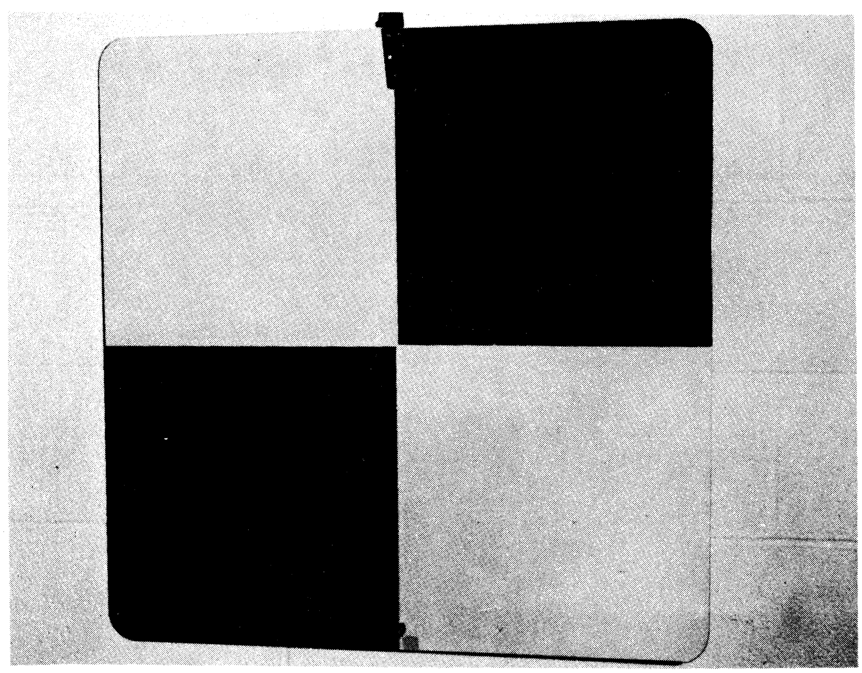

Figure 3. Special high intensity sign.

The sign was mounted near the center of the existing overhead sign in order to closely approximate a realistic height and entrance angle.

Readings were taken with no rotation at distances of 300, 450, 600, 750, and 900 feet (91.44, 137.16, 182.88, 228.60, and 274.32 m) from the sign, in both the left and right lanes, and with the car's headlights on both high and low beams. These readings were taken to obtain control data.

The final phase of data collection was the taking of readings from the same special sign at angles of 6, 9, and 12 degrees.(5) These angles placed the sign perpendicular with the line of sight at distances of 500, 600, and 700 feet (152.40, 182.88, and 213.36 m), respectively, which encompassed the range of maximum brightness for encapsulated lens materials (see Figure 4). The test vehicle was a 1970 Plymouth Fury.

DATA ANALYSIS

All data were compiled and prepared for both numerical and graphical presentation. All statistical parameters were computed on a 95% confidence level. Computer analysis techniques were employed whenever possible to minimize the possibility of errors in calculation.

The analysis was based on readings taken at the test site during two nights over a one-month period. The brightness was measured on the background and legend materials of the signs and from more than one location on the sign in order to find a representation of the average brightness. A total of 120 readings were recorded for the before conditions and 576 readings for the after conditions. The before and after data and results of preliminary calculations appear in the Appendix.

The before and after data were compared for all corresponding parameters. These comparisons, shown in the Appendix, relate the averages, standard deviations, t values, and statistical significance.

Inspection of the Appendix leads to the conclusion that rotation of the special sign made no statistically significant difference in the nighttime brightness. In only one set of readings did a significant difference appear and this difference was not consistent at different distances from the sign. However, Figures 5-8 show that generally the brightness values were maximum at observation points facing the sign after it had been rotated. While this effect was not altogether unexpected, it is encouraging, since there might exist some road geometry in which this principle might be used.

SUMMARY OF FINDINGS

The findings of this study may be summarized as follows:

1. The rotation of the specially fabricated sign made no statistically significant difference in the average nighttime brightness.

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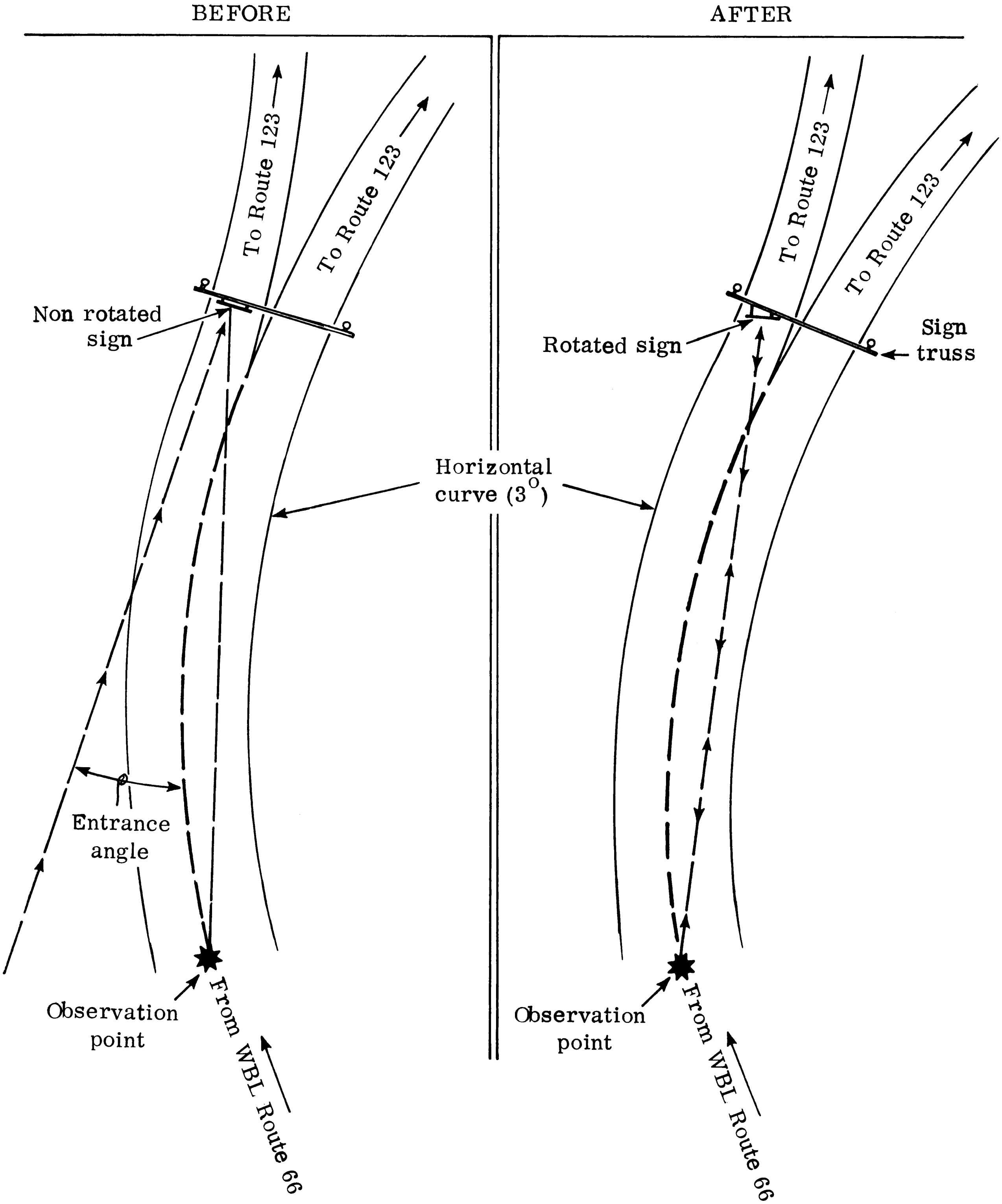

Figure 4. Rotation scheme–before and after conditions.

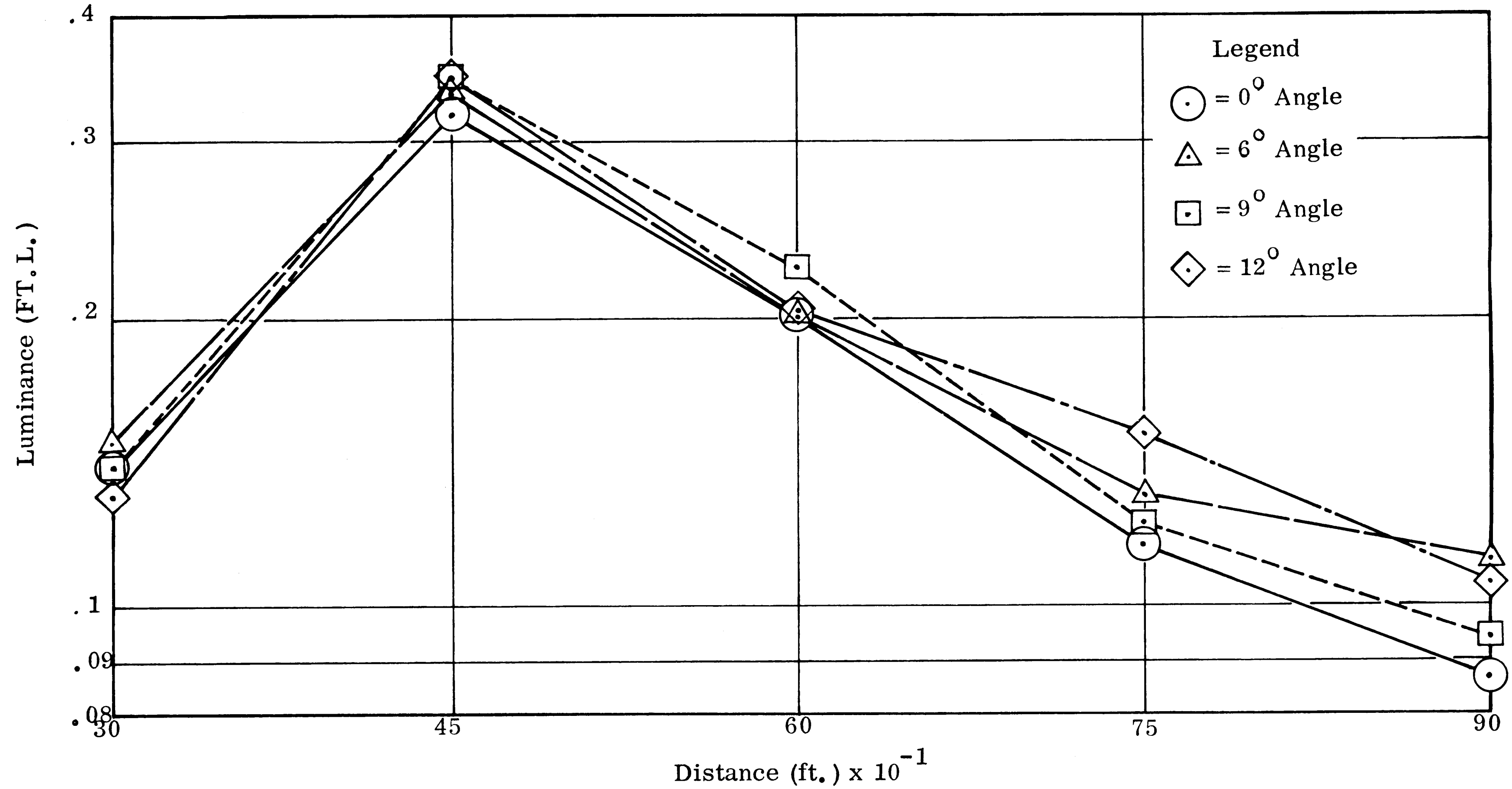

Figure 5. Nighttime luminance of rotated sign backgrounds versus distance for overhead signs, high beams. Basic conversion units: 1 ft.= .3048 m ; 1 foot lambert = 3.426 cd/m^2.

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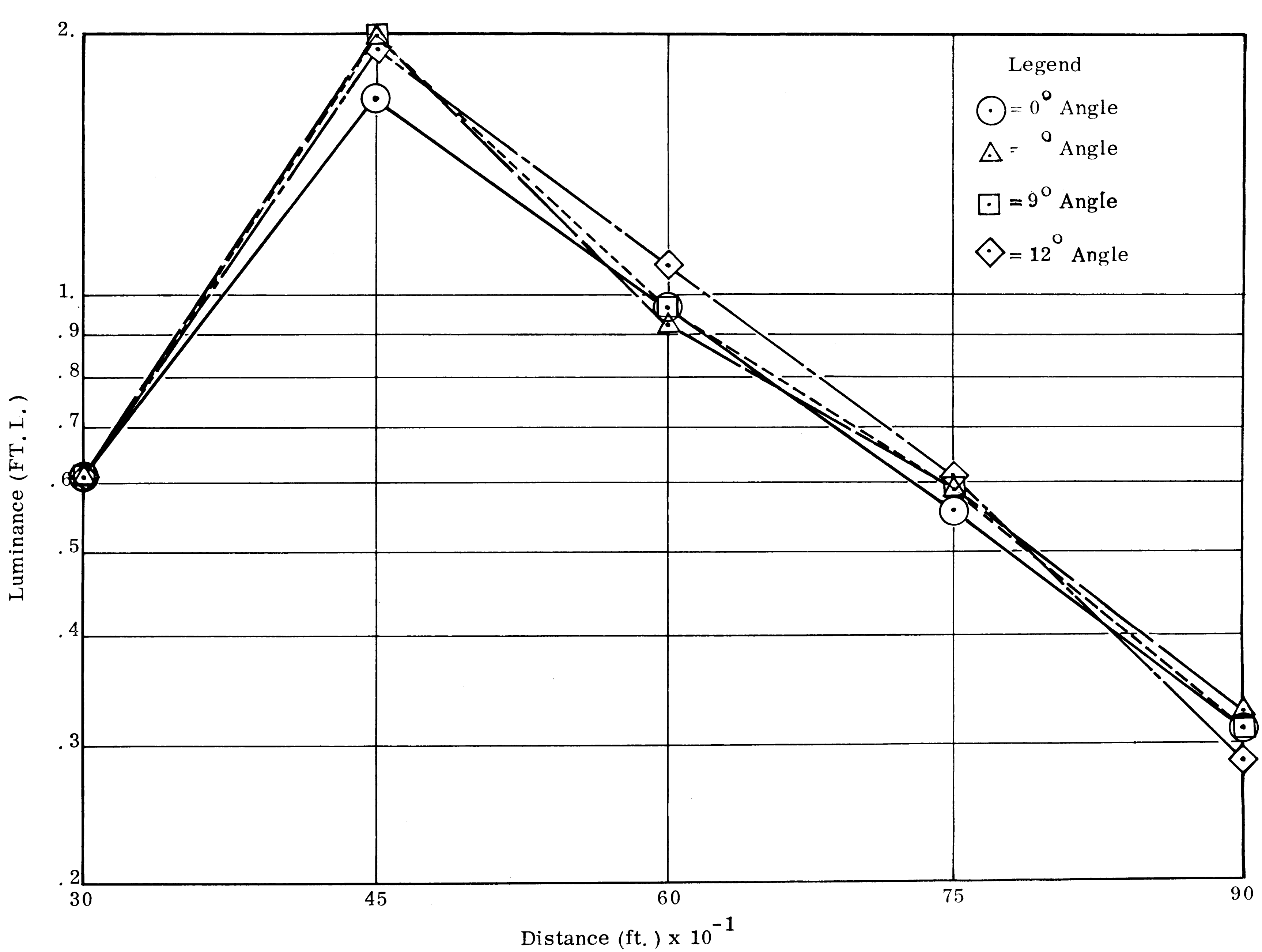

Figure 6. Nighttime luminance of rotated sign legends versus distance for overhead signs, high beams. Basic conversion units: 1 ft.= .3048 m ; 1 foot lambert = 3.426 cd/m^2.

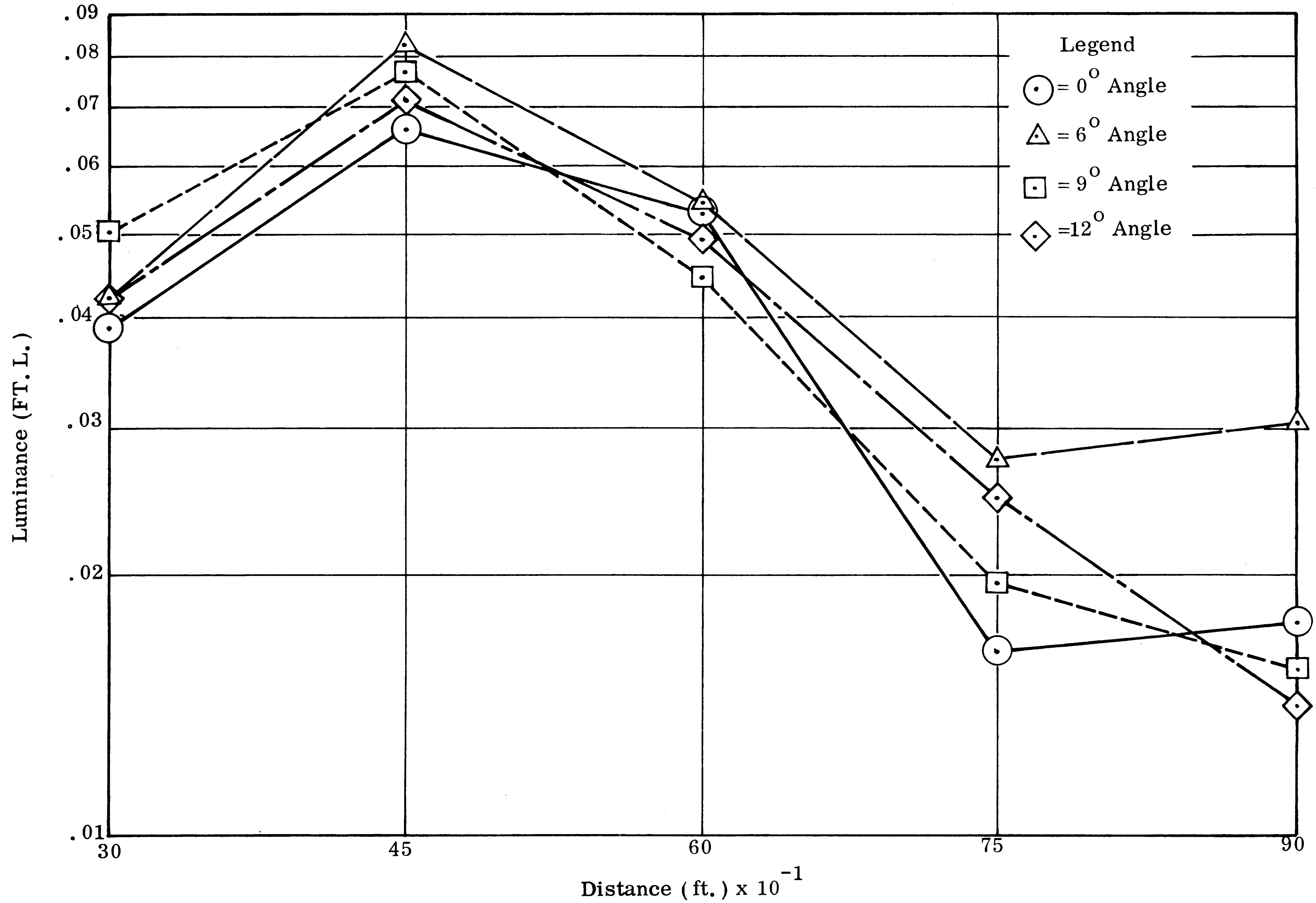

Figure 7. Nighttime luminance of rotated sign backgrounds versus distance for overhead signs, low beams. Basic conversion units: 1 ft. = .3048 m ; 1 foot lambert = 3.426 cd/m^2.

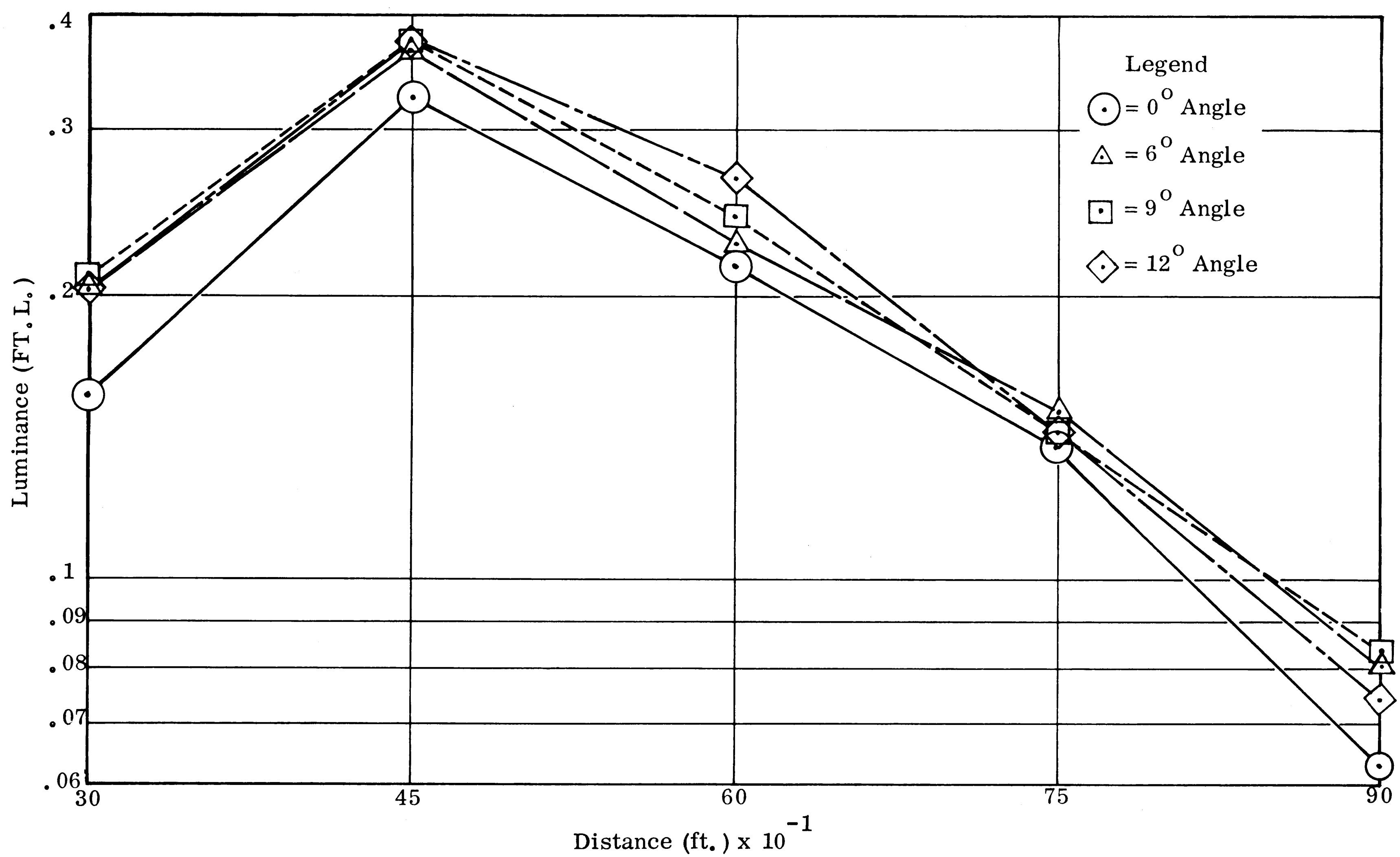

Figure 8. Nighttime luminance of rotated sign legends versus distance for overhead signs, low beams. Basic conversion units: 1 ft. = .3048 m ; 1 foot lambert = 3.426 cd/m^2.

2. The findings of past studies were supported by the indication that when the entrance angle is at a minimum, the brightness will be at a maximum.

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that while the actual average brightness of the special sign did increase in many cases, there was no statistically significant improvement on a 95% confidence level.

It is recommended that further study be made on possible schemes which would improve the brightness of overhead signs utilizing high intensity sheeting in order that this material may be used in as many situations as possible and thus increase the potential savings from its use.

REFERENCES

1. Robertson, R. N., "Evaluation of High Intensity Sheeting for Overhead Highway Signs", Virginia Highway and Transportation Research Council, Charlottesville, Virginia (to be published).

2. Straub, Arthur L., and Terrence M. Allen, "Sign Brightness in Relation to Position, Distance and Reflectorization", Highway Research Record No. 146, Highway Research Board, Washington, D.C., 1957.

3. Road Designs and Standards, Location and Design Division, Virginia Department of Highways, Richmond, Virginia, 1974.

4. Introduction to Reflective Materials, Traffic Control Products Division, Minnesota Mining and Manufacturing Company.

5. Youngblood, W. P., and H. L. Woltman, "A Brightness Inventory of Contemporary Signing Materials for Guide Signs", Highway Research Record No. 377, Highway Research Board, Washington, D.C., 1971.

SUMMARY OF NIGHTTIME LUMINANCE DATA IN FOOTLAMBERTS AND STATISTICAL SIGNIFICANCE

HEADLIGHTS: HIGH BEAM
OBJECTIVE: BACKGROUND
NO ROTATION

Dist. (ft.)	No. of Readings	Avg. Reading	Standard Deviation
300	2	.1415	.0163
450	4	.3187	.0547
600	4	.1972	.0304
750	4	.1162	.0390
900	4	.0850	.0291

ROTATION: SIX DEGREES

Dist. (ft.)	No. of Readings	Avg. Reading	Standard Deviation	t value	Significance
300	2	.1505	.0106	.9257	No
450	4	.3392	.0871	.3986	No
600	4	.1975	.0327	.0134	No
750	4	.1307	.0247	.6281	No
900	4	.1115	.0484	.9384	No

Basic Conversion Units
1 Foot = .3048 m
1 Footlambert = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: HIGH BEAM
OBJECTIVE: BACKGROUND
ROTATION: NINE DEGREES

Dist. (ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.1410	.0014	.0611	No
450	4	.3442	.1056	.4288	No
600	4	.2205	.0603	.6900	No
750	4	.1215	.0298	.2159	No
900	4	.0932	.0256	.4231	No

ROTATION: TWELVE DEGREES

Dist. (ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.1315	.0148	.9084	No
450	4	.3430	.1080	.4014	No
600	4	.2007	.0311	.1609	No
750	4	.1497	.0500	1.056	No
900	4	.1057	.0660	.5739	No

Basic Conversion Units

1 Ft. = .3048 m

1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: HIGH BEAM
OBJECTIVE: LEGEND
NO ROTATION

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation
300	2	.6135	.1011
450	4	1.730	.4215
600	4	.9720	.1085
750	4	.5602	.0945
900	4	.3047	.0645

ROTATION: SIX DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.6175	.0969	.0571	No
450	4	2.087	.6243	.9478	No
600	4	.9467	.1604	.2612	No
750	4	.5962	.1204	.4704	No
900	4	.3220	.0533	.4135	No

Basic Conversion Units

1 Ft. = .3048 m

1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: HIGH BEAM
OBJECTIVE: LEGEND
ROTATION: NINE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.6300	.0877	.2465	No
450	4	1.992	.6313	.6903	No
600	4	.9820	.0665	.1571	No
750	4	.5897	.1188	.3886	No
900	4	.3052	.0800	.0097	No

ROTATION: TWELVE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.6305	.0587	.2908	No
450	4	1.960	.6275	.6085	No
600	4	1.099	.2408	.9617	No
750	4	.6147	.1250	.6955	No
900	4	.2792	.0242	.7403	No

Basic Conversion Units
1 Ft. = 3048 m
1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: LOW BEAM
OBJECTIVE: BACKGROUND
NO ROTATION

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation
300	2	.0390	.0000
450	4	.0670	.0047
600	4	.0537	.0017
750	4	.0165	.0093
900	4	.0177	.0091

ROTATION: SIX DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.0425	.0049	1.399	No
450	4	.0842	.0211	1.591	No
600	4	.0545	.0076	.2054	No
750	4	.0275	.0141	1.302	No
900	4	.0305	.0152	1.445	No

Basic Conversion Units
1 Ft. = .3048 m
1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: LOW BEAM
OBJECTIVE: BACKGROUND
ROTATION: NINE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.0505	.0064	3.550	Yes
450	4	.0775	.0225	.9136	No
600	4	0.450	.0101	1.698	No
750	4	.0197	.0160	.3458	No
900	4	.0157	.0067	.3539	No

ROTATION: TWELVE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.0415	.0064	.7718	No
450	4	.0715	.0114	.7298	No
600	4	.0495	.0210	.3986	No
750	4	.0247	.0112	1.126	No
900	4	.0142	.0085	.5621	No

Basic Conversion Units
1 Ft. =.3048 m
1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: LOW BEAM
OBJECTIVE: LEGEND
ROTATION: NINE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.2100	.0113	1.398	No
450	4	.3780	.0955	.8079	No
600	4	.2462	.0173	1.973	No
750	4	.1505	.0415	.3499	No
900	4	.0845	.0133	.9034	No

ROTATION: TWELVE DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.2025	.0191	1.171	No
450	4	.3790	.0816	.9198	No
600	4	.2700	.0562	1.705	No
750	4	.1455	.0669	.1151	No
900	4	.0760	.0174	.5042	No

Basic Conversion Units
1 Ft. = .3048 m
1 Ft.L = 3.426 cd/m^2

APPENDIX CONTINUED

HEADLIGHTS: LOW BEAM
OBJECTIVE: LEGEND
NO ROTATION

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation
300	2	.1580	.0735
450	4	.3325	.0597
600	4	.2185	.0221
750	4	.1412	.0332
900	4	.0647	.0413

ROTATION: SIX DEGREES

Dist. (Ft.)	No. of Readings	Avg. Reading	Standard Deviation	t Value	Significance
300	2	.2060	.0141	1.282	No
450	4	.3710	.1014	.6543	No
600	4	.2310	.0265	.7245	No
750	4	.1550	.0434	.5051	No
900	4	.0835	.0115	.8770	No

Basic Conversion Units
1 Ft. = .3048 m
1 Ft.L = 3.426 cd/m^2