Legibility of Freeway Guide Signs as Determined by Sign Materials

ROGER W. MCNEES AND H. DEXTER JONES

In this paper, results of an operational study investigating the legibility distance of unlighted overhead guide signs are presented. Opaque sign backgrounds, as well as engineer, superengineer, and high-intensity reflective sheetings were used in combination with button-removable and high-intensity reflective copy. There was no significant difference between lighted and unlighted signs (lighted, 787.7 ft; unlighted, 788.1 ft) by sign material. Several sign combinations performed better than others. Engineer reflective sheeting was legible at more than 900 ft both on the lighted and on the unlighted routes, whereas engineer reflective sheeting with high-intensity stick-on copy was legible at 775 ft (lighted) and 646 ft (unlighted). The following combinations were visible at more than 800 ft: superengineer/button (863 ft), high-intensity/stick-on (825 ft), and superengineer/stick-on (811 ft).

For several years, many states have experienced problems with the lighting equipment on large overhead freeway guide signs. The lighting equipment in most cases is over 15 years old and needs replacing. The replacement of this equipment will cost on the order of billions of dollars and does not include future cost of electricity to power these lighted signs.

This problem has forced many states to issue informal guidelines with respect to maintenance of lighting for freeway guide signs. These informal guidelines generally state that noncritical guide sign lighting will not be replaced after the lighting has burned out. In these noncritical situations, power to the sign lights will be disconnected. California has petitioned the U.S. Department of Transportation for relief from the lighting requirements for overhead guide signs in the *Manual on Uniform Traffic Control Devices* (MUTCD) *(1)*. California has cited the massive cost of replacing literally thousands of overhead guide signs with new lighting equipment, conduit, and electrical lines.

The U.S. Department of Transportation, specifically FHWA, has taken the position that all overhead guide signs will be lighted when the background is not reflectorized and the sign has a critical sight distance less than 1,100 to 1,200 ft. Section 2A-16 of the MUTCD *(1)* specifically states the following:

> Regulatory and warning signs, unless excepted in the standards covering a particular sign or group of signs, shall be reflectorized or illuminated to show the same shape and color both day and night. ALL OVERHEAD SIGN INSTALLATIONS SHOULD BE ILLUMINATED WHERE AN ENGINEERING STUDY SHOWS THAT REFLECTORIZATION WILL NOT PERFORM EFFECTIVELY. Reflectorization, non-reflectorization, or illumination of guide signs shall be as provided in subsequent sections.

The MUTCD *(1)* addresses the reflectorization of freeway guide signs in Section 2E-6, the expressway sign section.

> Letters, numerals, symbols, and border shall be reflectorized. The background of expressway guide signs may be reflectorized or non-reflectorized. However, the mixing of signs with reflectorized and non-reflectorized backgrounds in the same general area should be avoided.
>
> In general, where there is no serious interference from extraneous light sources, reflectorized signs will usually be adequate. However, on expressways where much driving at night is done with low beam headlights, the amount of headlight illumination incident to an overhead sign display is relatively small. Therefore, all overhead sign installations should normally be illuminated. The type of illumination chosen should provide effective and reasonably uniform illumination of the sign face and message. When a sign is internally illuminated the requirement for reflectorized legend and border does not apply.

Various methods used for illumination are specified in Section 2A-17 of the MUTCD *(1)*.

1. A light behind the sign face, illuminating the main message or symbol, or the sign background, or both, through a translucent material; or
2. An attached or independently mounted light source designed to direct essential uniform illumination over the entire face of the sign; or
3. Some other effective device, such as luminous tubing or fiber optics shaped to the lettering or symbol, patterns of incandescent light bulbs, or luminescent panels that will make the sign clearly visible at night.

The requirements for sign illumination are not considered to be satisfied by street or highway lighting, or by strobe lighting.

Jones and Raska *(2)* performed legibility studies in Houston, El Paso, and Dallas. Their findings indicated there was no significant difference in legibility distance between lighted and unlighted signs. The lighted signs had a legibility distance of 877 ft, the unlighted signs of 838 ft.

FREEWAY SIGN LEGIBILITY STUDY

Sixteen test signs, eight overhead and eight ground-mount, were selected on two routes. Any sign mounted higher than 17.5 ft was classified as an overhead regardless of location within the visual view. All signs lower than 17.5 ft were classified as ground-mounts.

R. W. McNees, Texas A&M University System, 520 Blocker Building, College Station, Tex. 77843-3135. H. D. Jones, Texas State Department of Highways and Public Transportation, P.O. Box 1386, Houston, Tex. 77251-1386.

In the procedure used in the operational study, the true test sign was disguised. A normal eye pattern was desirable, but the subject was not told which sign was being evaluated. The subject was given a key word that had to be read aloud to the test administrator, who would record the legibility distance for at least one additional sign and the test sign. The test subject scanned all signs normally and read aloud the entire messages on the signs. The test administrator recorded the distance between the points at which the subject started reading the sign and passed the sign. Signs that the subjects misread or missed entirely were noted on the answer sheet and not included in the analysis of the data. Data not used in the analysis also included extremely short legibility distances created by vehicles that blocked the driver's vision or distracted the driver and extremely long distances caused by subjects who thought they knew what the message was but read it incorrectly. Table 1 presents the list of the key words, the number of signs with the key words, and the number of signs for which legibility data were collected. Table 2 presents illustrations of all test signs used in this study.

The objective of the study was to determine the legibility distance for lighted and unlighted freeway guide signs. Table 3 presents the factors considered—ambient weather, roadway geometrics, sign location, sign illumination, freeway illumination, background materials, and legend (copy) material.

Ambient Weather

Ambient weather was determined at the time the test run was conducted. Signs read in the rain were so marked in the comments section on the data form. There were limited rain data and no fog data.

Roadway Geometrics

Roadway geometrics were obtained from existing roadway plans. Horizontal curves of less than 2 degrees were considered tangent sections of freeway. Texas generally will not place freeway guide signs on roadway with horizontal curvatures greater than 4 degrees. Curvatures greater than 4 degrees create target value problems instead of legibility problems. The driver must detect and recognize a freeway guide sign before reading the sign.

Sign Location

The location of the sign is another important factor that affects both the sign's target value and legibility. The two locations considered in the study were overhead and side (shoulder) mount. The overhead signs consisted of overhead bridge mounts, median mounts, cantilever mounts, and elevated T-mounts within freeway right-of-way. All of these structures are more than 17.5 ft above the roadway surface. Shoulder mount signs are signs less than 15 ft in height placed to the right or left of the main lanes. The retroreflective properties of background sheeting are affected by the sign's position. Shoulder-mounted signs reflect more light with less traffic and low-beam light usage. Overhead signs reflect less light back to the driver under the conditions just described. For overhead signs to reflect enough light for the green background to project back

TABLE 1 LIST OF KEY WORDS, NUMBER OF SIGNS WITH KEY WORDS, AND NUMBER OF SIGNS FOR WHICH LEGIBILITY DISTANCE WAS RECORDED

Key Word	Number of Signs with Key Words	Number of Signs for Which Legibility Distance Was Recorded
Post Oak	3	2
Richmond	4	2
Chimney Rock Road	2	2
Bellaire Blvd.	2	2
Houston Baptist Univ.	1	1
Airport Blvd.	3	2
Sugarland	2	2
Williams Trace Blvd.	5	3
West Bellfort Ave.	1	1
Bissonet Street	3	3
Fondren Road	2	2
Hillcroft Ave.	1	1
San Felipe	2	1
Washington Ave.	3	3
Scott Street	2	1
Long Drive	5	3
Monroe Drive	4	3
Edgebrook Drive	2	2
Almeda-Genoa Road	5	3
Ellington Field	4	2
El Dorado Blvd.	2	2
Choate Road	3	2
Clearwood Drive	3	2
Broadway Blvd.	3	2
Frontage Road	1	1

TABLE 2 LISTING OF TEST SIGNS WITH MESSAGES, LOCATION OF SIGNS, TYPES OF MOUNT AND MATERIAL, AND CODE NUMBERS

SIGN	LOCATION	MOUNT	TYPE	CODE
San Felipe Rd NEXT RIGHT	I-610 WEST	GND	OP/BC	R1NB9
Westcott St Washington Ave 1 MILE	I-10 EAST	OVH	HI/SO	R1NB10
Westcott St 1/2 Washington Ave 1/2 T C Jester Blvd 1 1/4	I-10 EAST	OVH	OP/SO	R1NB11
Scott St EXIT 3/4 MI	I-610 SOUTH	OVH	SE/BC	R2SB2
Long Dr S Wayside Dr	I-610 SOUTH	GND	HI/SO	R2SB4
TEXAS 3 Monroe Dr	I-45 SOUTH	OVH	HI/SO	R2SB7
Edgebrook Dr Clearwood Dr RIGHT LANE	I-45 SOUTH	GND	SE/SO	R2SB9
South Shaver Rd Almeda Genoa Rd RIGHT LANE	I-45 SOUTH	GND	OP/SO	R2SB10
FM 1959 Ellington Field Choate Rd EXIT 1 7/10 MI	I-45 SOUTH	OVH	OP/BC	R2SB11
FM 1959 Ellington Field Choate Rd RIGHT LANE	I-45 SOUTH	GND	EG/BC	R2SB12
El Dorado Blvd	I-45 SOUTH	OVH	EG/BC	R2SB14
FM 1959 Ellington Field Choate Rd RIGHT LANE	I-45 SOUTH	GND	EG/SO	R2NB2
Almeda-Genoa Rd NEXT RIGHT	I-45 SOUTH	GND	OP/BC	R2NB4

TABLE 2 *continued*

SIGN	LOCATION	MOUNT	TYPE	CODE
Post Oak Blvd 1/4 San Felipe Rd 3/4 Westhiemer Rd 3/4	I-610 WEST	OVH	HI/BC	R1SB2
Richmond Ave ↗	I-610 WEST	OVH	EG/SO	R1SB4
Chimney Rock Rd City of Bellaire ↗	US-59 SOUTH	GND	HI/BC	R1SB6
Bellaire Blvd EXIT 1 MILE	US-59 SOUTH	OVH	OP/BC	R1SB8
Houston Baptist University NEXT RIGHT	US-59 SOUTH	GND	SE/BC	R1SB9
Airport Blvd Kirkwood Rd EXIT 1/2 MILE	US-59 SOUTH	GND	OP/SO	R1SB11
ALT 90 - SPUR 41 Sugar Land ↓ EXIT ONL	US-59 SOUTH	OHV	SE/SO	R1SB13
Williams Trace Blvd ↗	US-59 SOUTH	GND	EG/BC	R1SB15
Williams Trace Blvd ↗	US-59 SOUTH	GND	EG/SO	R1NB1
W Bellfort Ave NEXT RIGHT	US-59 SOUTH	GND	HI/SO	R1NB2
Bissonnet St EXIT 3/4 MILE	US-59 SOUTH	GND	SE/SO	R1NB4
Fondren Rd Bellaire Blvd ↗	US-59 SOUTH	OVH	EG/BC	R1NB7
Hillcroft Ave ↗	US-59 SOUTH	OVH	SE/BC	R1NB8

TABLE 2 *continued*

SIGN	LOCATION	MOUNT	TYPE	CODE
Clearwood Dr Edgebrook Dr EXIT ↓ 3/4 MILE	I-45 SOUTH	OVH	EG/SO	R2NB5
Clearwood Dr Edgebrook Dr RIGHT LANE	I-45 SOUTH	GND	SE/BC	R2NB6
Park Place Blvd Broadway Blvd 1 MILE	I-45 SOUTH	OVH	HI/BC	R2NB7
Park Place Blvd Broadway Blvd NEXT RIGHT	I-45 SOUTH	GND	HI/BC	R2NB8
Calais Rd Holmes Rd EXIT MILE	I-610 SOUTH	OVH	SE/SO	R2NB12
Scott St 1 1/4 MILE	I-610 SOUTH	OVH	OP/SO	R2NB13

All Ground Mounted Signs (GND) are unlighted.
All Overhead Mounted signs (OVH) are unlighted.

to the driver requires the vehicle's headlamps to be on high beam or sufficient stream traffic to illuminate the sign. Strong ambient illumination will also aid the detection, recognition, and legibility of overhead guide signs. All these conditions are present on urban freeways.

Illumination

Sign and freeway illuminations were also considered in this study. The sign lighting was either on or off. The same freeway lighting conditions were used along the two routes. Both test sections started in highly complex, ambient illumination areas and continued into the suburbs where freeway lighting was discontinued. In this way, the complexity of the background varied along the route. Shoulder-mounted signs are not lighted in Texas. Signs were illuminated along one route and not along another.

Sign Materials

The sign background materials for this study were the most commonly used materials—opaque, engineer reflective sheeting, superengineer reflective sheeting, and high-intensity reflective sheeting. These are the typical types of background used in the United States. With respect to the amount of reflectivity, opaque has the least and specific high-intensity most.

Legend Materials

Finally, the copy materials used in this study were removable button and high-intensity stick-on types. These materials have similar retroreflective properties and produce the greatest contrast ratios. The inclusion of other copy material was not considered for economic reasons.

Test Routes

Two test sections in Houston, Texas, used both loop and arterial freeways. Each test section was approximately 50 mi long. The length of the sections concerned the researchers because of the possibility of fatigue to the drivers. The pilot study conducted before the legibility study indicated that the drivers did not incur any unusual fatigue due to the length of the test sections.

The first test section (Route 1) commenced on I–610 west and proceeded southwest on US–59. The return trip was over the same two routes and a portion of I–10 eastbound. This route covered a total of 48 mi. The second test section (Route 2) began on I–610 south and proceeded southbound on I–45 to El Dorado Boulevard. The return route was over the same two freeways and ended at Texas 288 where it began. This test section was 54 mi in length.

Each route contained a full complement of freeway guide signs according to the experimental design. Both overhead and shoulder-mounted guide signs were included on both routes. To avoid a learning effect due to test drivers repeating the test, the I–10, I–610W, and US–59 route had all overhead signs lighted, whereas the I–610S and I–45 route had all the overhead signs

TABLE 3 FACTORS USED IN THE LEGIBILITY STUDY

Sign Background Material

a) Opaque

b) Engineer Grade Reflective Sheeting

c) Super Engineer Grade Reflective Sheeting

d) High Specific Intensity Reflective Sheeting

Sign Copy Material

a) Removable Button

b) High Specific Intensity Stick-On

Ambient Weather

a) Clear

b) Rain

c) Fog

Roadway Geometrics

a) Horizontal and/or Vertical Alignments Less Than 2 Degrees

b) Horizontal and/or Vertical Alignments Greater Than 2 Degrees

Sign Function

a) Overhead Mounted Sign

b) Ground Mounted Sign

Sign Lighting

(This specifically applies to overhead mounted since ground signs are non-illuminated.)

a) On

b) Off

Freeway Lighting

a) On

b) Off

the driver was reading unlighted. This procedure allowed the test administrator to record legibility distance while not destroying the total distance traveled by the test vehicle in case any unusual event occurred.

A tape recorder was placed in the test vehicle for two purposes: to present the study objectives to the test drivers and to present the key words the drivers were to locate. The second function of the tape recorder was to record the subjects' responses to determine their correctness.

TEST PROCEDURE

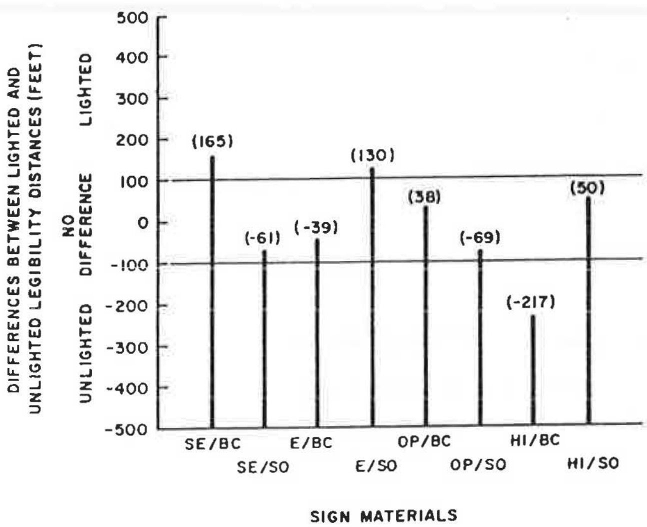
As the test drivers were traveling along a (previously described) route, key words were presented to them. A test driver would scan the horizon in a typical search fashion until a sign with the key words was located. The drivers did not know whether this sign would be a shoulder-mounted or overhead-mounted sign. If it was overhead, the mounting could be a median, sign bridge, cantilever, or raised T–mount. After the test drivers located the sign, they were required to read the entire message. This process continued until a different key word was presented.

To camouflage the true test signs from the driver, legibility distances for other signs with the same key word were also obtained. Drivers were never sure which signs were being studied. Signs in Table 1 with numbers had legibility distance determined.

STATISTICAL ANALYSIS AND RESULTS

A large amount of effort was spent to ensure that the reported measurements were recorded correctly on the data sheets and in the computer. Although this task does not appear to be worth mentioning, the size of the data set made it a slow and complicated process.

All signs along Route 1 were lighted; all signs along Route 2 unlighted. Distances of less than 200 ft were unusual and produced large differences in the matched pair of signs. These measurements were often the result of the test vehicle's being behind a truck that obscured the view. Such data were removed from the analysis, because they did not represent a true measure of the sign's legibility. The difference in legibility was calculated for each pair of signs by subtracting the unlighted distance from the lighted distance. Hence, a negative difference as in Figure 1 indicated that the unlighted sign of the pair was more legible than the lighted sign.



LEGEND

Background

E - Engineer Grade Reflective Sheeting
HI - High-Intensity Grade Reflective Sheeting
OP - Opaque
SE - Super - Engineer Grade Reflective Sheeting

Copy

BC - Button Removable
SO - High-Intensity Reflective Stick-On

FIGURE 1 Legibility distance difference between lighted and unlighted signs constructed using different sign materials.

An analysis of variance procedure was used to test for the equality of legibility distances under lighted and unlighted conditions for various types. The ordered differences in mean legibility distances for each test sign pair are listed in Table 4. The two-way analysis of variance model using distances as the dependent variable and the lighted and unlighted condition as the classification variable revealed there was a significant difference among these means ($p \leq .001$). The differences of the average distance for each pair (lighted and unlighted) are listed in Table 5 ordered from largest to smallest. That is, the largest difference in legibility distance was found for Sign Pair 15 (superengineer reflective sheeting button copy). This sign type has an average legibility distance 165 ft further under lighted conditions than unlighted. At the other extreme, Sign Pair 11 (high-intensity reflective sheeting with button copy) was seen 217 ft further under unlighted conditions than lighted conditions. A Duncans multiple-range test on these means revealed that Sign Pairs 14 and 15 (superengineer reflective sheeting with stick-on copy) were significantly better under lighted conditions. Sign Pair 11 was significantly better under unlighted conditions. There was no significant difference among the other sign pairs. The sign's background, legend, and ambient illumination had significant effects on the sign's legibility distance.

Several parameters usually considered as reliable indications of both sign legibility and target value were not statistically reliable in this study. These parameters were background luminance, legend luminance, contrast ratios, and background complexity. Background luminance and legend luminance did not prove to be reliable indicators because of the variability of the data. It is virtually impossible to obtain the exact background and legend luminance at the instant each test driver passed the sign. It is impossible to get a high correlation between the legibility distance and luminance values in this situation. Field data of these parameters will not result in as high correlation values as laboratory or controlled field studies. The complexity of the background has an effect on both a sign's legibility and target value. Several studies *(3, 4)* have shown this effect and provided some methodology for understanding why it happens.

TABLE 4 SIGN MATERIALS LEGIBILITY, DISTANCE FOR LIGHTED AND UNLIGHTED CONDITIONS, RANKED BY LEGIBILITY DISTANCE

Rank Order	Sign Number	Sign Material	Overall Average	Lighted Distance	Sign Number	Sign Material	Unlighted
1	8	E/B	928	908	8	E/B	947
2	15	S/B	863	907	11	H/B	883
3	16	H/S	825	888	16	H/S	838
4	14	S/S	811	835	13	O/B	792
5	13	O/B	775	830	10	O/S	761
6	1	E/S	760	775	15	S/B	742
7	10	O/S	727	692	14	S/S	696
8	11	H/B	711	666	1	E/S	646

Background/Legend

Background

Opaque (O)
Engineer (E)
Super-Engineer (S)
High-Intensity (H)

Legend

Button (B)
Stick-On (S)

TABLE 5 ORDERED DIFFERENCES IN LEGIBILITY

Pair Number	Material	Difference of Mean Distances
15	SE/BC	165
14	SE/SO	139
1	ENG/SO	129
16	HI/SO	50
13	OP/BC	30
8	ENG/BC	-39
10	OP/SO	-69
11	HI/BC	-217

At present there is no methodology that provides numerical values for complexity that can be accurately correlated with legibility and target distance. In some situations the sign is placed in front of a light source, whereas in other situations light sources (fixed roadway illumination) are placed in close proximity to the sign face.

FREEWAY GUIDE SIGN LEGIBILITY STUDY RESULTS

Figure 1 shows the differences in legibility distance between lighted and unlighted signs for different sign material combinations. The two signs that performed extremely well in the lighted condition were superengineer reflective sheeting with button copy and engineer reflective sheeting with button copy. High-intensity reflective sheeting with button copy performed extremely well in the unlighted condition. The large distance may be the result of this sign's being in a rural location. All other combinations performed equally well in the lighted and unlighted conditions. A study of the signs' background and legend material indicated that the sign combination that had the best legibility distance in the unlighted condition was engineer reflective sheeting with button copy (947 ft). However, the variance was extremely large (253 ft). Such large variances are not acceptable. Some drivers could read the signs with this combination at 1,100 ft, whereas others could read them at 712 ft. The ideal sign would be one with a long legibility distance and a low variance. The low variance would mean that virtually all drivers could read the sign at the same distance. However, due to driver visual characteristics, this assumption may be unreasonable for sign qualities. Another characteristic the sign should have is that the difference between the legibility distance in the lighted and unlighted conditions be negligible. High-intensity reflective sheeting with button copy had the greatest differential between the lighted and unlighted condition and was best in the unlighted condition.

Table 6 presents the sign material combinations with their associated legibility distances in the lighted and unlighted conditions, and variance. In the lighted condition, superengineer reflective sheeting with button copy and engineer reflective sheeting with button copy had the longest legibility distances. High-intensity reflective sheeting with stick-on copy, opaque background with button copy, engineer reflective sheeting with stick-on copy, high-intensity reflective sheeting with button copy, and superengineer reflective sheeting with stick-on copy had the poorest legibility distances in the lighted condition, all having less than 700 ft. The lighted condition resulted in more uniform variances than the unlighted condition.

In the unlighted condition, engineer reflective sheeting with button copy was the only combination resulting in a legibility distance greater than 900 ft. High-intensity reflective sheeting with button copy, high-intensity reflective sheeting with stick-on copy, opaque with button copy, opaque with stick-on copy, and superengineer reflective sheeting with button copy had legibility distances ranging from 742 to 883 ft. Superengineer reflective sheeting stick-on copy and engineer reflective sheeting with stick-on copy had legibility distances less than 700 ft. The variance range was wider for the unlighted condition (82 to 235 ft) than for the lighted condition (116 to 189 ft).

TABLE 6 LEGIBILITY DISTANCE AND STANDARD DEVIATION FOR LIGHTED AND UNLIGHTED SIGNS, BY SIGN MATERIALS COMBINATIONS

Sign Material	Distance		Variance	
	Lighted	Unlighted	Lighted	Unlighted
SE/BC	907	742	153	82
SE/SO	635	696	164	156
E/SO	776	646	189	150
HI/SO	888	838	119	111
OP/BC	830	792	117	192
E/BC	908	947	169	235
OP/SO	692	761	117	103
HI/BC	666	883	162	185

TABLE 7 LEGIBILITY DISTANCE IN FEET PER INCH OF LETTER HEIGHT FOR 16-IN. LETTERS, LIGHTED AND UNLIGHTED, BY SIGN MATERIAL AND LOCATION

Material	Sign Location	Legibility Distance Lighted	Legibility Distance Unlighted
HI/BC	OVH	42	55
	GND	--	47
HI/SO	OVH	56	52
	GND	--	50
SE/BC	OVH	57	46
	GND	--	52
SE/SO	OVH	52	44
	GND	--	51
E/BC	OVH	57	59
	GND	--	50
E/SO	OVH	48	40
	GND	--	38
OP/BC	OVH	52	50
	GND	--	50
OP/SO	OVH	43	48
	GND	--	51

Engineer reflective sheeting with button copy was legible over 900 ft both in the lighted and unlighted conditions. This sign material combination has excellent legibility distance and provides over 11 sec of travel time for the motorist to change lanes; on most large freeways with 3 to 4 lanes, the driver would require between 900 and 1,300 ft depending on the freeway level of service and number of lanes *(5)*. This sign combination would provide sufficient distance if it were placed as close as 353 ft upstream from the exit.

In the lighted condition, the top two sign material combinations (engineer and superengineer button copy) account for 8 percent of the reduced legibility distance. The three sign material combinations (engineer reflective sheeting with button copy, superengineer reflective sheeting with button copy, and high-intensity reflective sheeting with high-intensity stick-on copy) account for 30 percent of the diminished legibility distance. In the unlighted condition, engineer reflective sheeting with button copy accounts for over 21 percent of the diminished legibility distance by itself. When high-intensity reflective sheeting with button copy is used, over 36 percent of the reduced legibility distance is accounted for. This analysis indicates that in the lighted sign conditions the use of superengineer reflective sheeting with button copy would reduce the legibility to the driver by 11 percent and the use of high-intensity reflective sheeting with stick-on copy would reduce the legibility distance by 2 percent of the engineer grade reflective sheeting with button copy. Nine percent of the original legibility distance is diminished by using superengineer reflective sheeting with stick-on copy; in the unlighted condition, the use of high-intensity reflective sheeting with button copy would reduce the overall legibility distance by 7 percent; the use of high-intensity reflective sheeting with stick-on copy would reduce the legibility distance by 13 percent.

Table 7 presents the legibility distances for each sign combination in the standard feet per inch of letter height. In this study, all signs used 16-in. lowercase letters. The lighted signs ranged from 37 ft/in. for high-intensity reflective sheeting with button copy to 57 ft/in. for engineer reflective sheeting with button copy and superengineer reflective sheeting with button copy. The unlighted overhead signs ranged from 38 ft/in. for engineer reflective with stick-on copy to 59 ft/in. for engineer grade with button copy. The ground-mount signs ranged from 38 ft/in. with engineer grade with stick-on copy to 51 ft/in. for superengineer with button and stick-on copy and opaque with stick-on copy. This analysis points out the nonsignificant differences with respect to sign lighting and sign location.

The legibility distance data indicated that in the lighted condition specular glare reduced the distance the drivers were able to read the sign with the exception of engineer reflective sheeting with button copy and high-intensity reflective sheeting with button copy. All other sign combinations were legible farther both with button and stick-on copy; the opaque background with stick-on copy was legible farther on ground-mount signs than on overhead signs. All other combinations were legible farther on overhead than on ground-mounted signs.

SUMMARY OF RESULTS

1. When considering sign lighting, legibility distance, and driver variability, high-intensity reflective sheeting with high-intensity stick-on copy, opaque background with button copy, and engineer reflective sheeting with button copy are all acceptable combinations for freeway guide signs.
2. Background materials for signs have a more significant effect on sign legibility than does legend material.
3. There is a greater driver variability in the unlighted signs (152 ft) than for the lighted signs (150 ft).
4. When considering the reading distance in inch per letter height, the lighted overhead signs ranged from 42 to 57 ft/in., and the unlighted sign from 38 to 59 ft/in.

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