base would be necessary to prevent lifting around the edges should be studied.

The longitudinal spacing of reflectors in this study was 24.4 m (80 ft) on tangents and 12.2 m (40 ft) on curves. Increased spacing would certainly lower installation and maintenance costs, but what effect this would have on the overall effectiveness of an installation is not known. Shorter spacing would result in increased costs but might help combat the effect of glare. Shorter spacing may also be necessary in areas of extremely high dirt accumulation such as intersections. Research into these areas may prove helpful. It could be hypothesized that extremely bright reflective devices could in themselves cause a glare problem if they were spaced too closely. However, none of the products evaluated in this study were found to cause such a problem.

Whether a highly visible, durable center-barrier installation has any beneficial effects on road safety could be studied to further justify general use of such devices. Before-and-after accident analysis and other traffic performance measurements, such as lateral placements and lane volumes under wet nighttime conditions, might be used in this endeavor. The installation of center-barrier delineators along with reflective pavement markers meant to perform in inclement weather might have a beneficial effect.

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The contents of this report reflect my views, and I am responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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Abridgment

Evaluation of Yellow-on-Brown Road Signs for the Adirondack Park

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In 1892, a state park was established in northern New York. This 23 413-km^2 (9000-$mile^2$) area, known as the Adirondack Park, is guaranteed by the state constitution to remain "forever wild." The Adirondack Highway Council, which is composed of several representatives of state agencies and the public, was convened in 1974 to formulate and implement a state policy of enhancing the appearance of park highways in the Adirondacks. In 1976 and 1977, the work of the council focused on the aesthetic appearance of road signs. They recommended that certain types of highway signs be colored yellow on brown rather than a standard white on green, blue, or brown. This combination was recommended because, over a 40-year period, these have come to be recognized as Adirondack Park colors. Thousands of brown wooden signs with yellow letters have been used throughout the park by the New York Environmental Conservation Department to identify camping areas, hiking trails, ski slopes, and other places of interest. In addition, because of a 1924 state law governing commercial signing, many private organizations and businesses in the park area have chosen to adopt these colors in their advertising.

Before a color change could be implemented, it was necessary to obtain a variance from nationally mandated signing standards. To obtain such a variance, it had to be shown that the new combination would perform as well as standard colors.

A review of existing literature showed several studies that related directly to the proposed research. Unfortunately, although each was complete within its own objectives, not enough information had been collected to answer our question: Would yellow on brown perform as well as standard color combinations for the general driving population? We also wished to survey the opinions of the motoring public on the proposed colors.

The study was divided into two phases: (a) aesthetic appraisal (both by photographic documentation and an opinion survey) and (b) measurements of visibility and legibility. This research is described in greater detail elsewhere (1).

AESTHETIC APPRAISAL

Investigation

A section of NY-28 and NY-30 between Indian Lake and Blue Mountain Lake in Hamilton County was reconstructed in 1976. In keeping with its designation as an environmental highway project, yellow-on-brown signs were installed along this highway on an experimental basis. These include minor destination signs (D 15 series), which are normally white on green; parking and rest area signs (D 30 series), which are normally white on blue; and miscellaneous information signs (D 61 series), which are also normally white on green. D 15 and D 30 signs were constructed of brown engineering-grade reflective sheeting with yellow engineering-grade cutout letters and applied to metal substrates. The D 61 signs were wooden with routed letters and painted yellow on brown.

This 18-km (11-mile) highway section contains a total of 33 yellow-on-brown signs in the three series listed. They range from 0.61 to 3.05 m (2 to 10 ft) wide and from 45.7 to 142.2 cm (18 to 56 in) high. Length of message varies from two to nine words. In addition, several small symbol signs identify hiking trails, snowmobile trails, and bicycle routes.

Because of the availability of these yellow-on-brown signs, the site's location in the heart of the park, and heavy tourist traffic during the summer, this section was ideal for the aesthetic appraisal, which consisted of photographic documentation and a driver opinion survey.

Photographic Documentation

For the photographic documentation, four yellow-on-brown signs were selected on the basis of sight distance and background: one D 15, two D 30s, and one D 61. Overlays constructed of engineering-grade reflective sheeting and letters in the standard colors of white on green or blue duplicated each yellow-on-brown sign. The actual signs and standard-color overlays were photographed under five background conditions: winter (snow), spring (primarily brown background), summer (green background), fall (multicolored foliage), and night.

The color photographs and movies provide a comparative record of the yellow-on-brown signs and the standard white on green and blue. As might be expected, the photographic colors do not precisely match those experienced by the human eye, but representation was adequate in most cases to provide a sense of how a particular sign color fits into the highway environment. This documentation was particularly useful in examining camouflaging by roadside vegetation or background colors similar to the sign.

No distinct advantages are detectable for any of the colors from these photographs. Generally, the green and blue signs stand out better under spring and fall conditions, which present a primarily brown background. In summer, the brown signs appear to stand out better against the primarily green background. During winter (white background) and at night (black background), all three colors stand out well.

Opinion Survey

The opinion survey was conducted during the week of July 11 to 15, 1977; interview stations were set up at Indian Lake and Blue Mountain Lake. One interviewer was positioned at each station to solicit verbal opinions from drivers. Surveys were conducted both during daylight hours and after dark. Half the drivers were "alerted"—i.e., stopped at the station before entering the test section and requested to observe the highway signs ahead and be prepared to answer questions at the second interview station. The other drivers were "unalerted"—i.e., given no information until they were questioned at the second station as they left the test section.

To guard against biasing the answers by the methods used by the two interviewers, the wording of each question was rehearsed beforehand to ensure uniformity between the interviewers. The following principal questions were asked about the signs:

1. Did you have any trouble spotting the yellow-and-brown highway signs?
2. Did you have any trouble reading them?
3. Compared with normal road signs, how well do you think the yellow-and-brown signs complement the Adirondack environment?
4. Would you like to see more widespread use of yellow-and-brown signs in the Adirondacks?

The unalerted drivers were asked several preliminary questions to determine if they had noticed the yellow-on-brown signs. Because some noticed a number of different items along the roadway, it was occasionally necessary to direct their recollection to these signs in particular. This did not appear to bias results because most drivers tended to give specific answers one way or the other. However, all indefinite responses were counted as negative responses. Several additional questions were asked to obtain a driver profile. Drivers were classified by sex, age (as estimated by the interviewer), home address, and frequency of use of this highway section.

The geographic distribution of sample drivers and the overall results of the opinion survey are shown in Figures 1 and 2 respectively. All differences in tabulated data and potential recorder bias were examined statistically. The results shown in Figure 2 are very favorable toward yellow-on-brown signs. Three-fourths of the drivers thought these signs complemented the environment better than white on green or blue, and four-fifths favored more widespread use of this color scheme in the Adirondack Park. About five out of six expressed no difficulty in spotting or reading these signs. In addition,

1. No difference of opinion was found between tourists and local drivers,
2. Night drivers were much more observant and slightly more critical of the signs than daytime drivers, and
3. No difference of opinion was found among groups stratified by age or sex.

LEGIBILITY AND VISIBILITY

A 15-km (9-mile) section of NY-9H in Columbia County was selected as a test site because of its rural nature, low traffic, and absence of roadside lighting. Its abundance of long tangent sections allowed long sight distances, and its closeness to Albany simplified the logistics of conducting a large-scale test.

Within this section, 18 test signs were erected at random locations along various tangent sections. They included six from each of the three sign series installed on NY-28 and NY-30. Nine signs were yellow on brown, six were white on green, and three were white on blue. The materials, duplicating actual signs in the Adirondack Park, consisted of engineering-grade reflective sheeting and letters on metal substrates. Again, the yellow-on-brown D 61 series signs were routed letters on wooden panels painted (not reflectorized) yellow and brown. Series D letters 15.24 cm (6 in) high were used throughout.

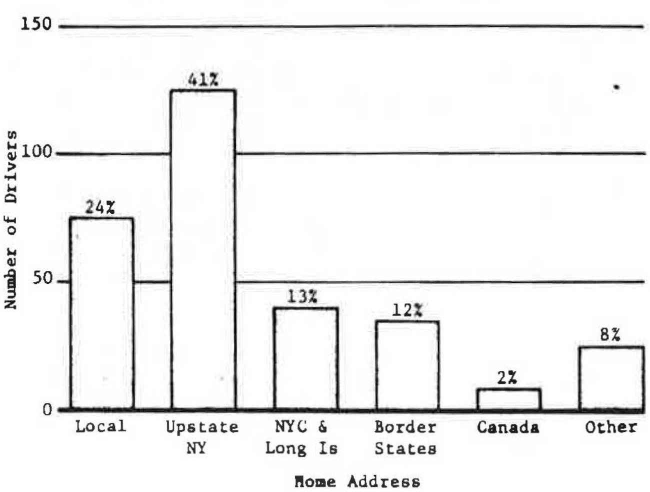
Each sign contained a nonsense message composed of words easily read but conveying no meaningful message to the reader. This type of message was used to ensure that the sign was read entirely and that the test subjects did not rely on glance recognition.

The subjects, employees of the main office of the New York State Department of Transportation (NYSDOT) in Albany, were screened in an effort to ensure that the sample would be representative of the normal driving population. Engineers and technicians involved in any phase of highway engineering were excluded. The visual acuity of each volunteer was tested by the NYSDOT Health Services Unit, which also checked for color blindness.

Sign legibility and visibility were measured under three sets of conditions—spring, summer, and night. (Winter measurements could not be obtained before the end of suitable snow cover in March.) Fifty subjects were tested in each group, and profiles for each group were balanced to the extent possible.

The test vehicle, a 1974 Matador station wagon, was equipped with a distance-measuring system capable of recording reactions of two test subjects simultaneously. To ensure valid results, specific detailed instructions were given to the subject before testing, and a series of practice measurements were made before reaching the test site.

Figure 1. Geographic distribution of 313 sample drivers.



Test Subject Profile

Profiles of test subjects were compiled in terms of driving experience, age, sex, and education. To the greatest extent possible, profiles were matched for each test group to guard against biasing results by the selection of sample characteristics. Subject profiles were also compared with the general driving population to ensure that results were valid on a general basis. Overall, the profiles appeared balanced and representative of the statewide driver population. Two significant exceptions were noted and considered during data analysis:

1. Because test subjects were solicited from within NYSDOT, the sample contained a large proportion of persons of working age.
2. Judging from the three parameters of annual distance driven, type of driving, and years of experience, it became apparent that relatively few inexperienced drivers were included in the sample.

Legibility and Visibility Distance

Visibility and legibility distances for the test signs are given in Table 1. In most cases, the yellow-on-brown signs could not be read from as far away as could white on green or blue. Although most differences were statistically significant, the absolute differences were small—11 percent in the extreme case. The average daytime legibility distance for the standard-color signs is 103 m (337 ft) compared with 99 m (325 ft) for yellow on brown. Traffic signs are commonly designed on the basis of 6 m of legibility distance for each centimeter of letter height (50 ft/in); this results in a legibility distance of 91 m (300 ft) for the test signs, which had 15.24-cm (6-in) letters. Both the standard and the special colors exceeded that value.

Visibility distances of yellow-on-brown signs were also slightly less, averaging 462 m (1515 ft) for all daytime readings compared with 493 m (1617 ft) for the

Figure 2. Summary of driver responses to opinion survey.

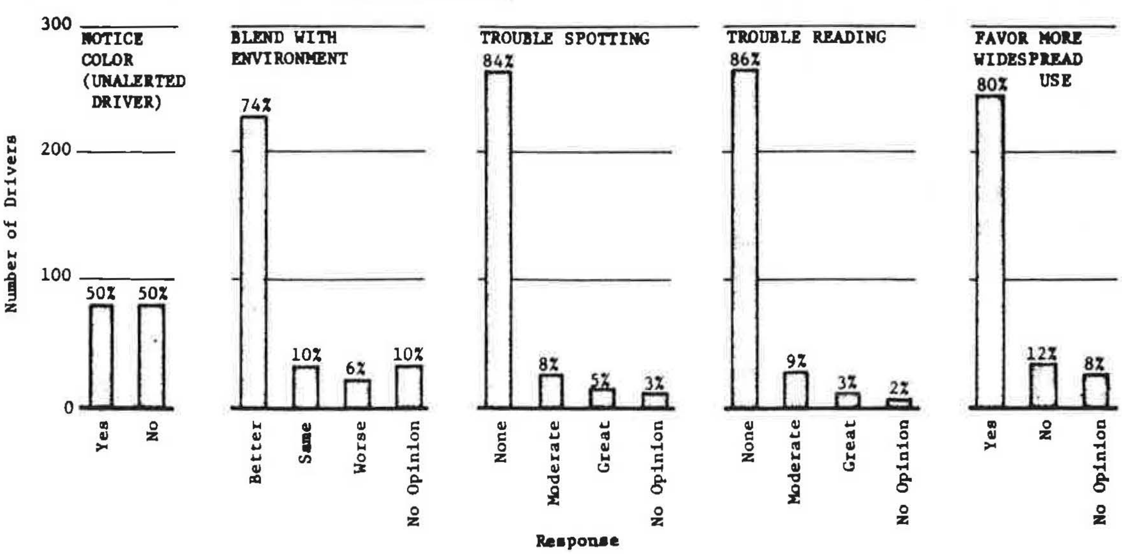


Table 1. Legibility and visibility distances for test signs.

		Spring			Summer			Night		
Item	Type of Sign	$\bar{X}$ (m)	s (m)	n	$\bar{X}$ (m)	s (m)	n	$\bar{X}$ (m)	s (m)	n
Legibility distance	Three-line blue	101	38	147	112	30	143	88	25	127
	Three-line brown	94	34	149	100	27	140	79	23	133
	Two-line green	98	36	148	106	27	147	80	23	133
	Two-line brown	92	33	147	103	28	142	77	24	131
	One-line green	93	32	148	107	27	142	81	23	128
	One-line brown	99	33	148	107	25	147	-[a]	-[a]	-[a]
Visibility distance	Three-line blue	593	186	135	511	136	141	413	132	134
	Three-line brown	472	167	142	422	170	142	399	99	135
	Two-line green	564	142	145	457	149	143	498	119	131
	Two-line brown	532	206	146	555	188	143	418	156	133
	One-line green	491	152	141	414	100	142	410	130	134
	One-line brown	477	150	130	445	133	130	-[a]	-[a]	-[a]

Note: 1 m = 3.3 ft.
[a]Not reflectorized.

standard colors. Again, although most differences in visibility distance in Table 1 are statistically significant, these small differences appear to have little practical meaning.

Specific Effects

Visibility and legibility distances were compiled with regard to the parameters of static visual acuity, color blindness, seating position, and background environment:

1. Generally, acuity correlated closely with both sign visibility and legibility. Unfortunately, we were not able to investigate the relation between aging and certain visual difficulties because of the relatively small sample of volunteers over age 60.
2. Differences appeared between color-blind subjects and the overall sample, but no particular problem is apparent for any one color.
3. Differences in readings could not be attributed to seating position for the daytime survey, but at night drivers were able to spot a sign more quickly than their passengers.
4. Spring readings were lower than summer readings, and night measurements were the lowest of the three surveys. Within each survey, however, the yellow-on-brown signs generally measured slightly lower than the standard-color signs.

CONCLUSIONS

1. All three sign-color combinations tested were legible beyond the accepted standard of 6 m/cm (50 ft/in) of letter height during daylight. This standard was published in 1939 (2) as a result of full-scale tests with black-on-white signs, and others (3, 4) have expanded on this initial research. Our study varied from its predecessors in that it combined (a) full-scale testing with (b) a relatively large number of subjects of various backgrounds by using (c) three different color combinations.
2. Differences in legibility and visibility among sign colors were small but statistically significant in some cases. Recent studies that have used colors other than black on white have reached this same conclusion (5, 6). But those studies were conducted primarily in the laboratory, and our study must be considered primarily a full-scale field test.
3. Driver parameters of age, sex, driving experience, and visual acuity could not be related to differences in performance among sign colors. It must be noted, however, that our sample included few inexperienced drivers and few over the age of 60.
4. Four-fifths of the drivers interviewed in an opinion survey in the Adirondack Park favored use of yellow-on-brown signs on park highways.
5. Color photographs confirm the importance of background color in sign visibility. Each color combination tested was more visible against some backgrounds than others.
6. More widespread use of yellow-on-brown information signs can enhance the parklike appearance of Adirondack Park highways with no loss in highway safety or motorist convenience.

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