EVALUATION OF WET BOTTOM SLAG BITUMINOUS WEARING COURSE, I 94 IN DEARBORN HEIGHTS

Final Report

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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of the shoulder. According to Gallagher and Meguide, contrast value predicts driver visibility of a simple target with great accuracy.[2]

The visual contrast is generally determined by the formula:

$$C = \frac{L_p - L_s}{L_p}$$

where C = visual contrast. Shoulder visibility is proportional to visual contrast; and,
L_p = luminance (brightness) of the pavement,
L_s = luminance of the shoulder.

The denominator, L_p, is that value of luminance to which the driver's eye is adapted. Normally, if two areas of different luminances split the field of view of an observer, the observer is adapted to the average of luminances of the two areas; however, in this instance, the motorist is usually adapted to luminance of the pavement because the motorist is looking at the pavement the majority of the time. Adaptation of the eye to a lower level of luminance emanating from a different area, such as the shoulder, would require an interval of time of approximately one second or more. If glare luminance is present, the denominator is increased by the value of the glare luminance, thereby lowering contrast (C).

Each year, except 1977, from 1976 to 1981, the east- and westbound shoulder luminances were measured. Several attempts to measure shoulder luminance were made in 1977 but the shoulders were extremely dusty. The westbound shoulders included about 1.5 miles of conventional bituminous concrete shoulder against which the wet bottom slag shoulders were to be compared. A Model 1980 Pritchard telephotometer located near the driver's eye position measured the luminance of the shoulder and pavement at a point about 75 ft from the driver. This area is one of two locations at which the average driver is looking a major portion of the time. The second of the two primary fixation areas for the typical driver is a region on the pavement approximately 250 to 300 ft from the automobile; however, this area is not well illuminated by standard headlighting so that the errors in the luminance measurements at that distance were large. Therefore, only luminance data at 50 to 100 ft from the vehicle were utilized for this project. Glare luminance was also measured because it was necessary to determine whether glare from headlights of approaching vehicles would negate the extra delineation provided by a darker shoulder.

[2] Gallagher, V. P. and Meguide, P. G., "Contrast Requirements of Urban Drivers," Report No. FHWA-RD-74-76, Federal Highway Administration, November 1974.

The telephotometer was adjusted to measure a solid angle of two degrees which approximates the size of the field of view which the human eye assimilates. Different vehicles were used in some years, so that the driver's eye position necessarily varied each time the vehicle dimensions changed. These small alterations in driver's eye position most certainly had an effect on the pavement luminance measurements; however, the variance in dimensions of the vehicles used were considered to be within the normal variance of dimensions of the vehicles in general use on the roadways. The speed of a test vehicle was held at about 45 mph.

Results

Table 1 shows night and day contrast levels from 1976 through the winter of 1981-82. Each contrast value listed is an average of dozens of contrast level calculations along the two-mile stretch of the project. With the exception of the 1981 contrast value, the contrasts were fairly uniform throughout the time span for the wet bottom slag bituminous shoulders. Glare luminance was about 0.015 to 0.020 ft-L when there was oncoming vehicle headlighting.

TABLE 1
VISIBILITY OR VISUAL CONTRAST
(Maximum Contrast is 1.00)

Year	Nighttime Contrast*		Daytime Contrast*	
	Pavement and Conventional Shoulder	Pavement and Wet Bottom Shoulder	Pavement and Conventional Shoulder	Pavement and Wet Bottom Shoulder
1976	0.21	0.51	-0.07	0.13
1978	-0.29	0.45	-0.16	0.29
1979	-0.35	0.48	-0.05	0.14
1980	-0.35	0.46	---	--
1981	-0.10	0.28	---	--
1981-82	0.18	0.54	-0.17	0.31

* Negative contrast denotes shoulders are brighter than pavement.

The decrease in visibility of the pavement/shoulder in the spring of 1981 was caused by a combination of dust and salt residue on the shoulder which increased shoulder brightness, thus decreasing the contrast between shoulder and pavement.

One extra evaluation of visibility was, therefore, conducted in January 1982 in order to confirm the apparent drop in contrast. This last evaluation showed that the previous levels of brightness contrast (1976-79) between the pavement and the wet bottom slag shoulders had been restored. There was little evidence of dust or salt on the shoulders by 1982.

Six years after the initial luminance measurements were completed, the contrast levels remain nearly the same as the original values for wet bottom slag shoulders. The contrast levels for conventional bituminous concrete shoulders were generally much lower and evidenced more year-to-year fluctuation than those contrast levels for wet bottom slag shoulders.

Theoretically, the visual contrast between a bituminous concrete shoulder and a bituminous concrete pavement would be nil. The actual contrasts measured varied from -0.35 to +0.21, depending on the amount of debris on the shoulders (negative contrast meaning that the shoulder is brighter than the pavement). The bituminous concrete shoulders usually had more dust on them than did the wet bottom slag shoulders.

The visibility of conventional bituminous concrete shoulders was both inadequate and unreliable since its visual contrast has vacillated from positive (darker than pavement) to negative contrast (lighter than pavement) and back, during the six-year evaluation period.

Wet bottom boiler slag aggregate bituminous shoulders had sufficient night visibility to be seen by 95 percent of the 20 to 40 year old drivers and by the average 60 year old driver in every year except 1981 when debris and salt residue covered the shoulders. Glare levels evaluated where oncoming headlights were present would have reduced visual contrast provided by wet bottom slag shoulders by 25 percent, resulting in poor visibility for the average 60 year old driver.

The slag shoulders also had barely sufficient daytime contrast in 1981-82 and also in 1978, to be differentiated from the pavement by the average driver. Because sunlight is, in general, diffuse or scattered compared to the highly directional nature of headlamp beams, daylight can result in reduced visual contrast between surfaces of different texture and reflectance. The human eye, therefore, may not perceive as great a difference in brightness between the pavement and the wet bottom slag shoulder in the daytime

as could be seen at night under headlamp illumination. Countervailing this is the ability of the human eye at the high daytime levels of illumination to be more sensitive to small differences in brightness. The net result is that the average driver may notice in the daytime the darker shoulder provided by wet bottom slag.

Wet bottom slag shoulder delineation has provided approximately twice the visibility that conventional bituminous shoulders have exhibited for over seven years since construction. It should also be noted that debris or salt deposits on the shoulder may obviate any shoulder delineation provided by darker shoulders, although wet bottom slag shoulders were affected to a lesser degree than were conventional bituminous concrete shoulders.

On the basis of earlier observations, the Department has recommended wet bottom slag as an acceptable optional shoulder aggregate, "...but that it should not be solely specified, especially because of its limited availability." Because of a switch to primarily gas-fired boilers, the original source of the wet bottom slag, The Detroit Edison Co., notified John Norton of the Construction Division that availability is limited. An enquiry directed to Consumers Power Co. revealed that they do have boiler bottom ash available from some of their plants.

Conclusions

Based on the above observations of the better visual contrast, it is recommended that wet bottom slag aggregate in bituminous concrete shoulders be used for the purpose of improved pavement/shoulder delineation, should it be available.

Because a reflectorized white stripe can improve visibility of the pavement edge by approximately 50 percent over that produced by wet bottom slag shoulders alone, it is recommended that edge striping be employed for additional delineation wherever possible in order that older drivers could perceive the pavement edge even where there is glare in the visual environment.