1294

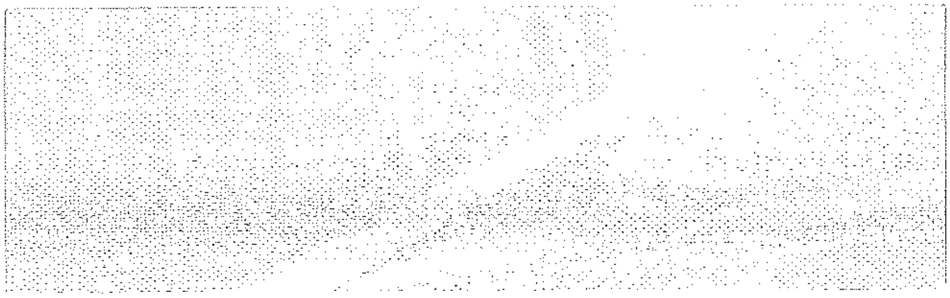
LOW-SLUMP HIGH-DENSITY CONCRETE BRIDGE DECK OVERLAY

MICHIGAN DEPARTMENT OF TRANSPORTATION

MATERIALS and TECHNOLOGY DIVISION

TG
325.6
S54
1988x
c.3

MDOT INFORMATION SERVICES
0049414



TG325.6 .S54 1988x c. 3
Low-slump high-density
concrete bridge deck overlay

TG325.6 .S54 1988x c. 3
Low-slump high-density
concrete bridge deck overlay

LOW-SLUMP HIGH-DENSITY CONCRETE BRIDGE DECK OVERLAY

J. E. Simonsen

Research Laboratory Section
Materials and Technology Division
Research Project 75 B-93
Research Report No. R-1294

Michigan Transportation Commission
William Marshall, Chairman;
Rodger D. Young, Vice-Chairman;
Hannes Meyers, Jr., Shirley E. Zeller,
William J. Beckham, Jr., Stephen Adamini
James P. Pitz, Director
Lansing, October 1988

The information contained in this report was compiled exclusively for the use of the Michigan Department of Transportation. Recommendations contained herein are based upon the research data obtained and the expertise of the researchers, and are not necessarily to be construed as Department policy. No material contained herein is to be reproduced—wholly or in part—without the expressed permission of the Engineer of Materials and Technology.

In 1975, the Department placed three experimental low-slump high-density (LSHD) concrete overlays using the Iowa mix design for the purpose of comparing their performance with that of latex-modified concrete (LMC) overlays. The structures selected for the experiment were: S03 of 33084, a three-span ramp structure 40 ft wide and 239 ft long carrying southbound I 496 traffic to eastbound I 96; S10 of 47065, two separate structures each 52 ft wide and 174 ft long carrying eastbound and westbound I 96 traffic over Grand River Ave.

Research Report No. R-1077 describes the construction and laboratory tests conducted at the time the overlays were placed. The report summary, based on field observations and laboratory test results, follows.

> In general, the low-slump overlay concrete is not easy to apply or finish. Weather is more of a factor than with latex-modified concrete as the prepared deck must be surface dry prior to brushing-in the slurry. Hot, windy weather compounds the consolidation and finishing problems of 1-in. slump mixes by speeding up slump loss.
>
> Low-slump concrete on this project was spread and leveled by hand with great difficulty before consolidation by the finishing machine. If the slump of the concrete is variable, the finishing machine will alternately ride up and then sink on the fresh concrete resulting in a wavy finished surface. This wavy surface produces a rough and unpleasant ride.
>
> If the slump of the concrete approaches 0-in. the finishing machine will tear the surface and this necessitates considerable hand manipulation to correct.
>
> The crew applying a low-slump concrete overlay on this first contract consisted of 12 workers; a latex-modified concrete overlay application will generally require about six workers. In addition, the low-slump concrete will require more time to apply than a latex-modified concrete. Wet curing time is also longer than that required of latex-modified concrete, three days as compared to two for latex.
>
> In general, the laboratory tests of the low-slump concrete showed good results. Generally the shrinkage shown for the low-slump concrete is about 0.50 mil/in. in 21 days of air drying, while a good latex-modified concrete of similar fine aggregate to total aggregate (FA/TA) ratio would show 0.30 mil/in. shrinkage under the same conditions. Bond strength, however, was quite good indicating the shrinkage rate is not detrimental to the bond, at least in the small bond durability test specimen.

The low-slump concrete showed about 1.3 percent moisture loss in 21 days of air drying while a good latex-modified concrete of similar FA/TA ratio would show 0.9 percent moisture loss under the same conditions. This indicates the low-slump concrete is more permeable than latex-modified concrete. To ensure the same protection against chloride ion penetration as the latex-modified concrete the low-slump cement-rich concrete would have to be thicker. The Department currently requires 2-in. low slump as an alternate to 1-1/2 in. of latex concrete.

It was anticipated that the construction disadvantages associated with LSHD overlays would be overcome as contractors gained experience and the overlay was approved as an alternate to the latex-modified concrete overlay. Fourteen LSHD overlays were placed in 1977-78 and several new decks were protected using this type of overlay during the 1978 construction seasons (Table 1). However, placement and finishing problems persisted and the LSHD overlay has not been permitted for use since 1978.

TABLE 1
LSHD OVERLAYS

	Bridge Number	Location
1977	B02 of 50111	WB I 94 Ramp over Clinton River Spillway
	B03 of 50111	EB I 94 WB over Clinton Rd.
	S04 of 82022	I 94 WB over Merriman Rd.
	S05 of 82022	I 94 EB over Middlebelt Rd.
	S07 of 82022	I 94 EB over Inkster Rd.
	S08 of 82022	I 94 WB over Inkster Rd.
	S10 of 82022	I 94 WB over Ecorse Rd.
	S11 of 82022	I 94 EB over Beech-Daly Rd.
	S22 of 82251	I 94 W-S Ramp
	S29 of 82251	I 94 W-S Ramp
1978	*S30 of 25132	Selby St. over I 475
	*S31 of 25132	Coldwater Rd. over I 475
	*S45 of 25132	I 475 Ramp over Horton Ave.
	*S46 of 25132	I 475 Ramp B over I 475
	*S47 of 25132	I 475 Ramp C over Ramp D
	*S48 of 25132	I 475 Ramp E over Ramp F
	*S49 of 25132	Cornell Ave. over I 475
	*S51 of 25132	Russel Ave. over I 475
	R01 of 63022	I 96 EB over GTW RR
	R01 of 63022	I 96 WB over GTW RR
	R02 of 63022	I 96 EB over C&O RR
	R02 of 63022	I 96 WB over C&O RR

*New decks protected with LSHD overlay

Although the use of the LSHD overlay was discontinued after the 1978 construction season, evaluation of the three experimental overlays proceeded by conducting periodic visual inspections, taking core samples for chloride penetration, checking for delamination, and making copper-copper sulphate half-cell measurements. This brief report covers the results of a 10-year evaluation period.

Visual Inspection

The observed defects in the overlays at the age of seven, nine, and eleven years are summarized in Table 2. All decks exhibited craze cracking which has increased in severity with time and has been present in the surfaces since construction. The severity of the cracking at the present time is illustrated in Figure 1. Transverse cracks have developed only in the S03 overlay and currently amount to only a total of 48 ft. Spalling has also occurred only in the S03 overlay and amounts to a total of 4 sq ft. The spalling is confined to the end edges and joints in the overlay (Figs. 2 and 3).

TABLE 2
VISUAL INSPECTION RESULTS

Bridge Number	Overlay Age, years	Observed Deterioration			
		Craze Cracking, percent	Transverse Cracks, ft	Spalls, sq ft	Delamination, sq ft
S03 of 33084	7	100	15	4	10
	9	100	48	4	18
	11	100	48	4	262
S10 of 47065, WB	7	100	--	-	--
	9	100	--	-	--
	11	100	--	-	--
S10 of 47065, EB	7	100	--	-	--
	9	100	--	-	--
	11	100	--	-	*

*Delamination of an area of about 4 sq ft has occurred since the 1986 survey.

Delamination

Delamination, or separation of the overlay from the original concrete, was checked using a chain drag. A total of 262 sq ft of delamination was found on S03 during the last survey conducted in 1986. The two S10 bridge overlays were free of delaminations. However, since the 1986 survey, a small area (about 4 sq ft) on S10 eastbound has broken out and is patched with bituminous material (Fig. 4).

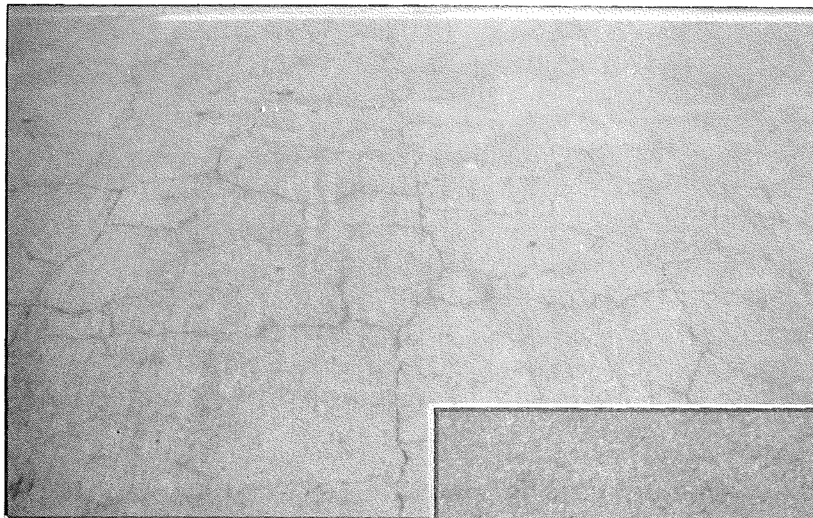


Figure 1. Typical craze cracking of LSHD experimental overlays.

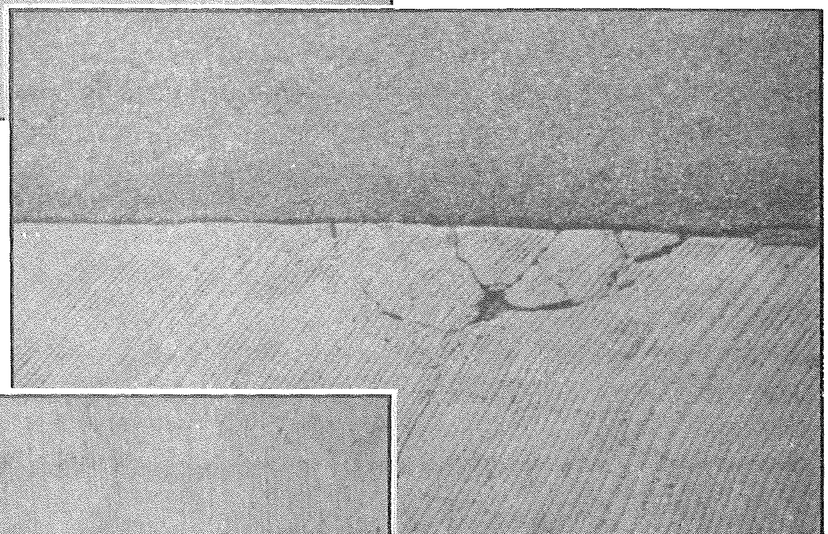


Figure 2. Spall at joint between deck overlay and pavement.

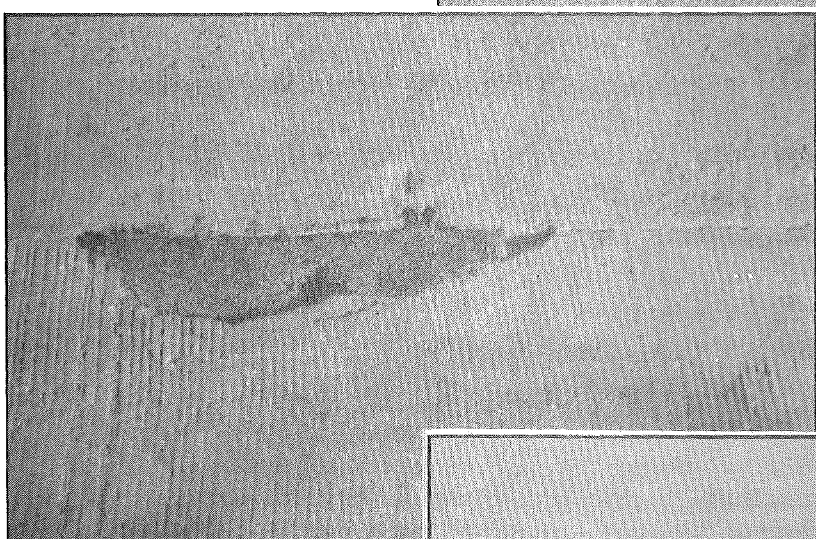


Figure 3. Spall along longitudinal joint.

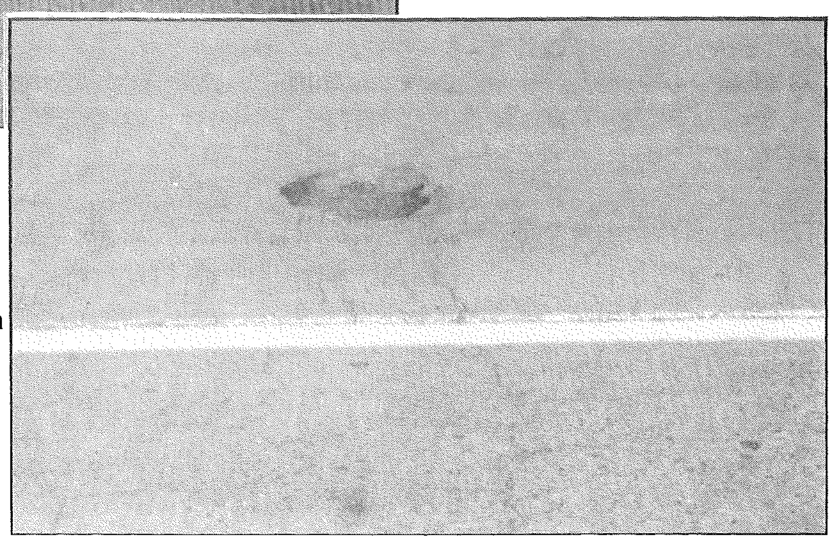


Figure 4. Surface repair in overlay on S10 eastbound.

Chloride Content

Samples of the overlay concrete were obtained at six locations on each bridge in 1976, 1982, and 1986. The concrete was sampled at 1/2-in. increments to the 2-in. level which was the thickness of the overlay. In 1976 the sampling of the 1-1/2 to 2-in. layer was omitted.

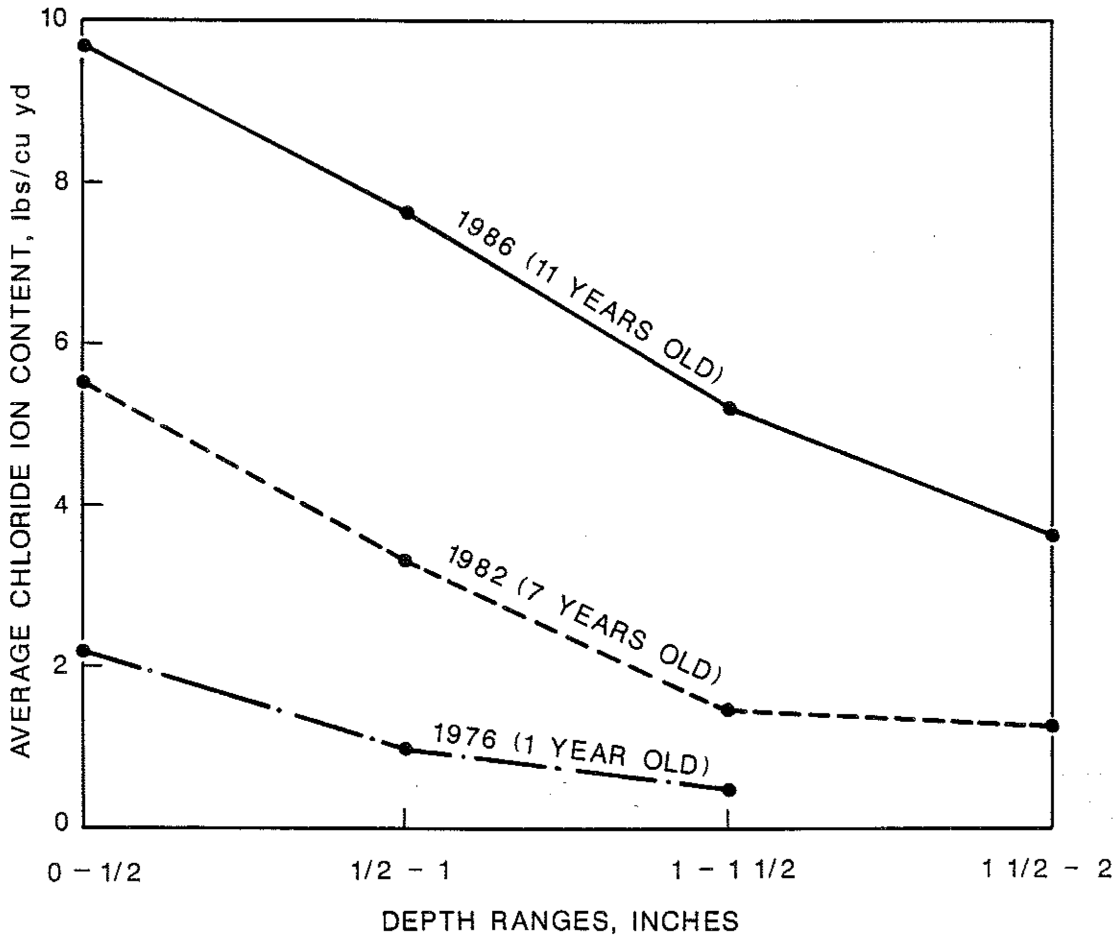


Figure 5. Progressive penetration of chloride ions into overlay.

The results of chloride analyses are shown graphically in Figure 5. The graph shows the average chloride ion content of all three decks at the different depths for each of the three sampling years. In 1976, one year after construction, it appears that the chloride had not as yet penetrated into the underlying concrete. In 1982, after seven years, the average chloride content in the lower 1/2 in. of the overlay was 1.3 lb/cu yd. By 1986 the chloride content of this level had increased to 3.7 lb/cu yd.

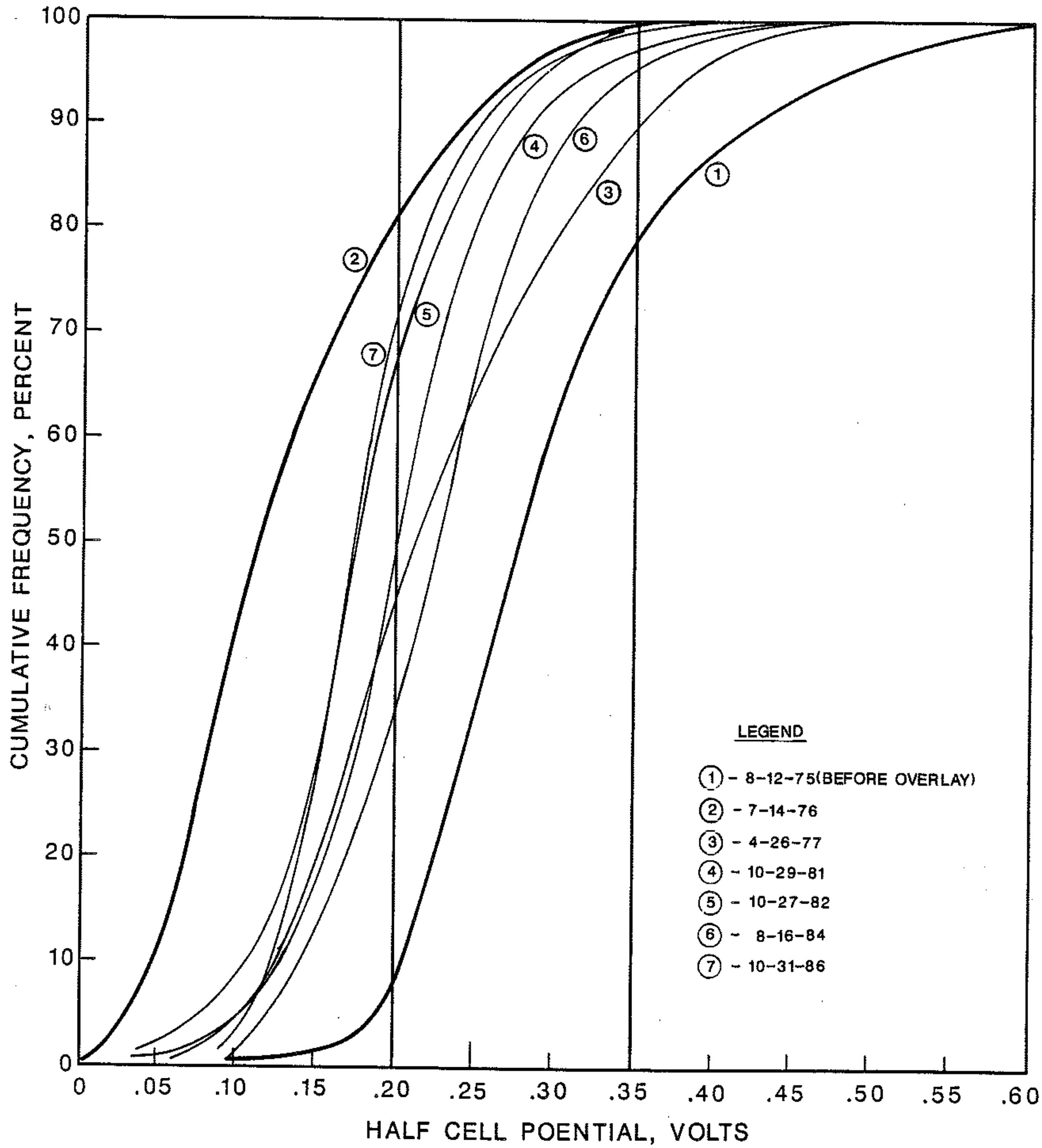


Figure 6. Cumulative frequency distribution curves of half cell potentials for S03 of 33084.

Half-Cell Potentials

Half-cell potential measurements were made on the three decks in 1975 before the overlays were placed. Since then, six more measurements were made, one in each of the following years: 1976, 1977, 1981, 1982, 1984, and 1986. These data are presented as cumulative frequency distribution curves in Figure 6 (S03), 7 (S10 Westbound), and 8 (S10 eastbound).

The normal shift of the curves from right to left (decrease in corrosion activity) that occurs when comparing 'before' and 'after' overlay readings is noticeable on the figures. Generally speaking, subsequent readings fall between the 'before' and 'after' overlay curves indicating that the corrosion activity has not as yet reached its pre-overlay level. It can also be noted that the bulk of the readings are still below 0.35 v, the value at which active corrosion is considered to be present.

Conclusions

The long-time performance observations of the experimental overlays confirm earlier laboratory analysis with respect to shrinkage or craze cracking of the overlay (Fig. 1). The LSHD overlay is somewhat more permeable than the LMC overlay, but its bonding property to the underlying concrete is comparable to the LMC overlay. Based on the half-cell potential measurements there apparently has been no increase in the areas of active bar corrosion since the overlays were placed.

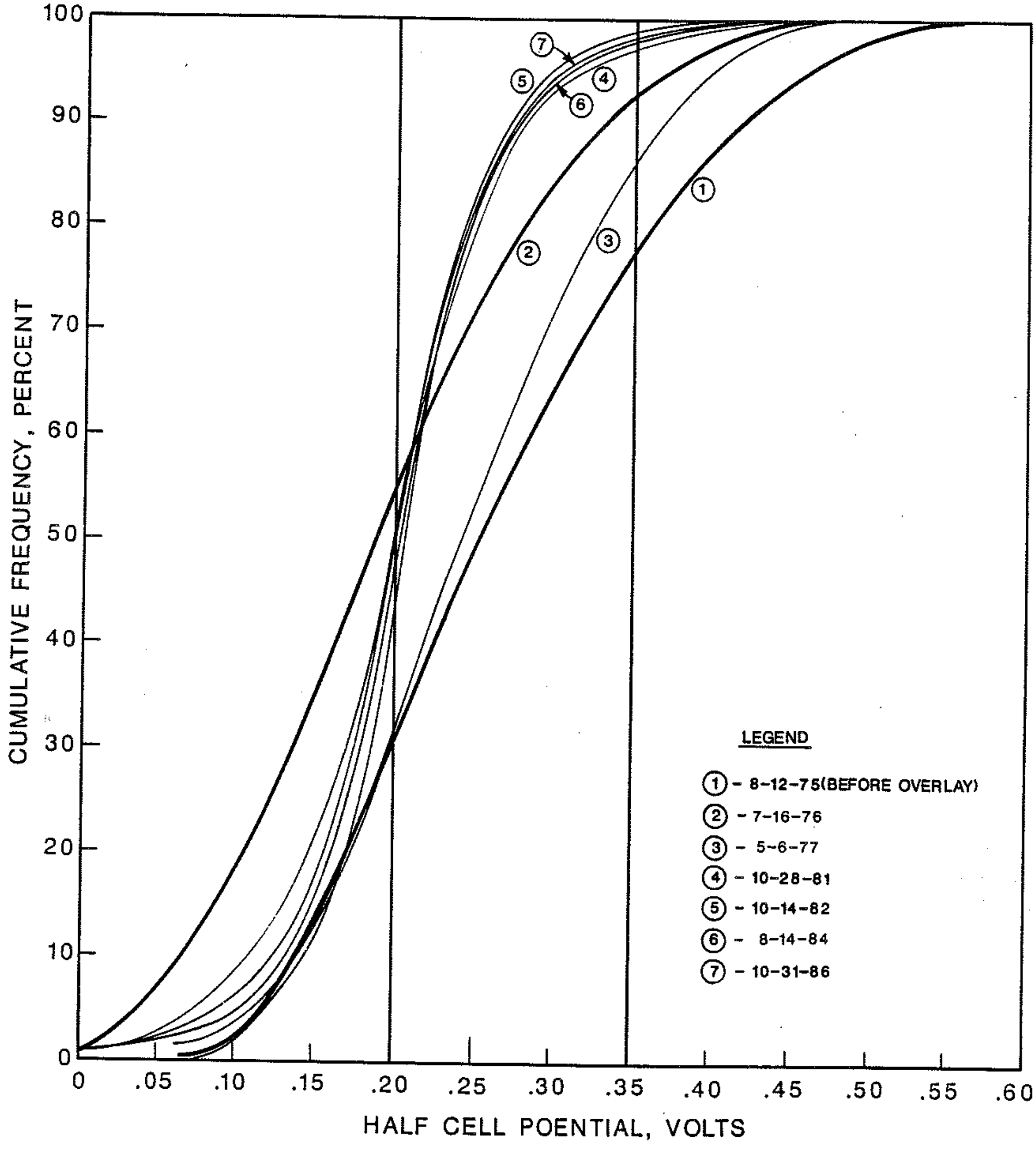


Figure 7. Cumulative frequency distribution curves of half cell potentials for S10 of 47065, westbound.

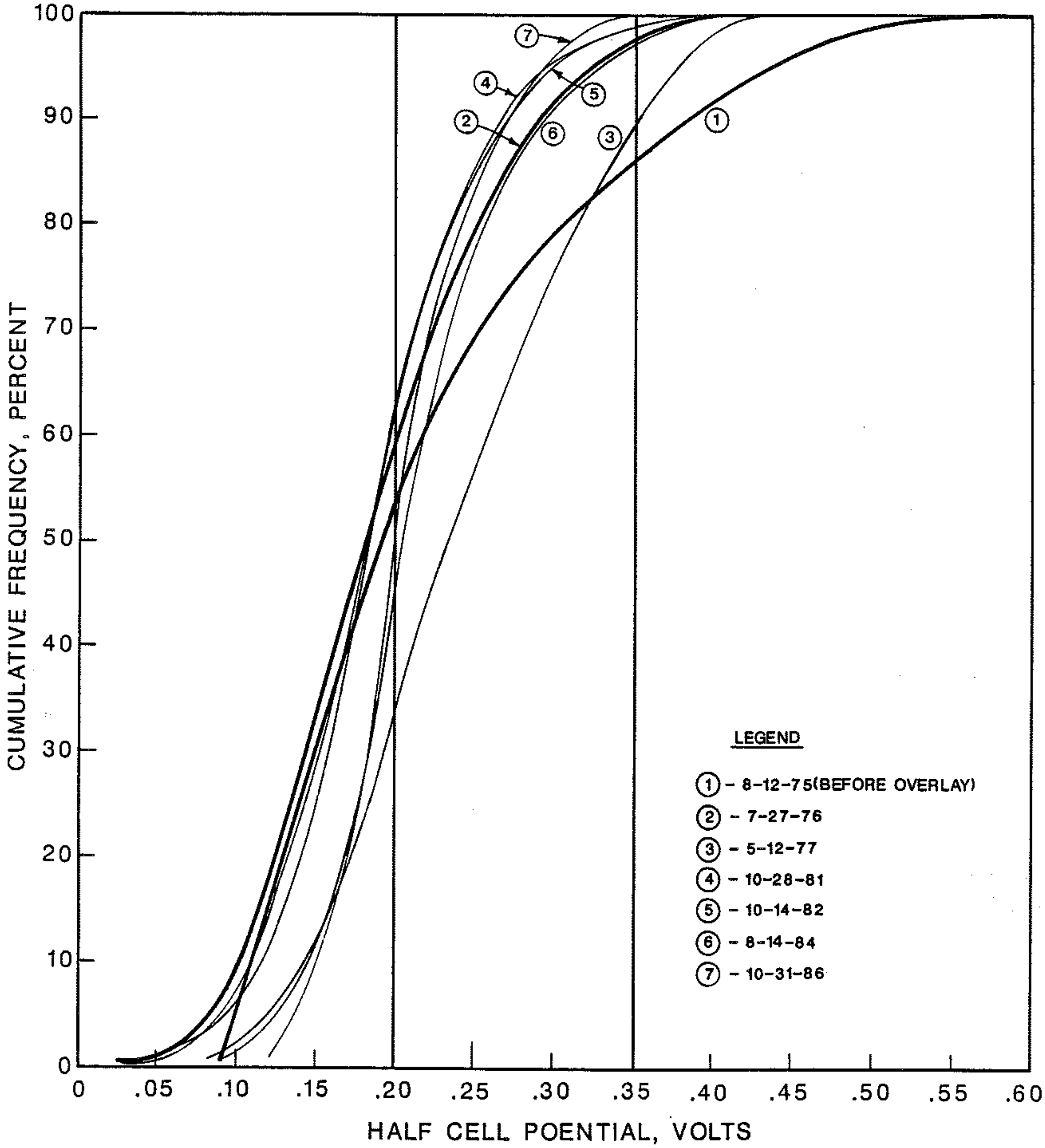


Figure 8. Cumulative frequency distribution curves of half cell potentials for S10 of 47065, eastbound.