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DEPARTMENT OF TRANSPORTATION
Bureau of Materials and Physical Research

FINAL REPORT ON LINSEED OIL RETREATMENTS TO CONTROL SURFACE DETERIORATION OF CONCRETE BRIDGE DECKS

by

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16. Abstract

This study was undertaken to determine the value of, the optimum cycle for, and the optimum rate of application for linseed oil retreatments of concrete bridge decks to control surface scaling. A total of 141 bridge decks which were new, five years old, or ten years old when treated initially were retreated at intervals of two, three, four, five or six years. The results of the study indicate that scaling of bridge decks is not a serious problem in Illinois, new bridge decks are more receptive to the benefits of linseed oil treatments than are older ones, and the optimum interval between linseed oil treatment is approximately four years under conditions prevailing in Illinois.

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INTRODUCTION

Scaling is a type of disintegration of portland cement concrete that develops as a flaking-off of the surface mortar. Under extreme conditions it may proceed to considerable depth in the slab. The action takes place in surfaces subjected to water and cycles of freezing and thawing. The presence of deicing chloride salts greatly aggravates the action.

Portland cement concrete which is not air-entrained will almost certainly suffer scaling if the surface is subjected to applications of chloride salts for snow and ice removal. Ample evidence is available from both laboratory tests and from practical experience to show beyond doubt that concrete containing a reasonable quantity of entrained air (currently specified at 4 to 7 percent in Illinois) is practically immune to scale. Nevertheless, scaling has been sufficiently prevalent through the years since the use of deicing chemicals became a common practice even where air entrainment has been specified that concern has existed regarding its development. In a survey conducted in Illinois in 1960 covering over 500 bridge structures constructed after 1947 with air entrainment specified, up to 13 percent were found to show some degree of scale.[1] A substantial number of additional structures that could not be observed because of bituminous resurfacing undoubtedly also had been affected by scale.

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1. J. D. Lindsay, "A Survey of Air-Entrained Structures in Illinois," HRB Bulletin 323 (1962).

Beginning in 1945 and until July 1961, an air content of from 3 to 5 percent was specified for portland cement concrete in Illinois. Beginning in July 1961 and until March 1964, a higher range of from 4 to 6 percent was specified. Since March 1964, the range has been specified at 4 to 7 percent. Beginning in April 1960, it was further required that the air content of each load of concrete brought to the jobsite be determined by test before acceptance.

Ample laboratory evidence also has been assembled to show that linseed oil coatings will enhance the resistance of portland cement concrete to chloride salt scale. One good source of information on this subject is National Cooperative Highway Research Program Report 16.[2] Field evidence of the value of linseed oil coatings has been far less definitive than the laboratory evidence and alone probably could not serve to justify general use of the linseed oil treatment.

Because of what appeared to be a sharp increase in the scaling of bridge decks taking place with an ever-increasing use of chloride salt deicents, the Illinois Division of Highways in 1962 undertook an extensive program of deck treatment with a 50:50 (by volume) boiled linseed oil-mineral spirits mixture. The history of deicent usage in Illinois prior to and during the period of study is shown in Figure 1. During that year and in the following two years, almost every exposed concrete deck under

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2. M. Jack Snyder, "Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals," NCHRP Report 16 (1965).

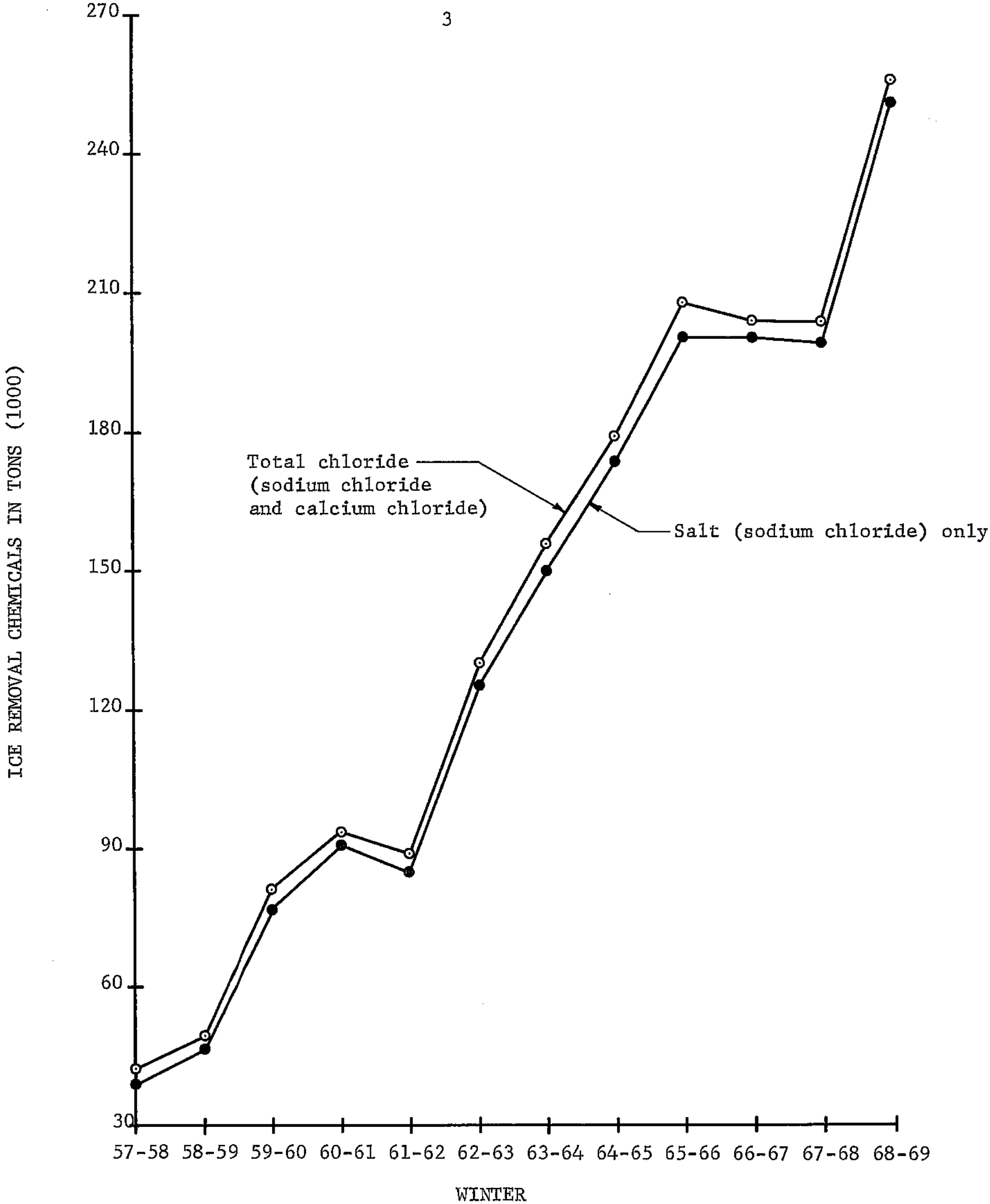

Figure 1. Twelve-year history of chloride salt usage on Illinois highways.

the jurisdiction of the Division (approximately 4,000) was treated. Also beginning in 1962, the Illinois Division of Highways adopted the policy of treating all newly constructed decks as part of the construction contract. This policy remained in force until 1967 when certain new decks were provided with a coal tar-fiber glass protective interlayer membrane and a bituminous concrete surfacing. In 1970 the present policy of providing interlayer membranes and bituminous concrete wearing surfaces for all new decks was adopted.

Illinois pavements have been noted to be less prone to scale and for several years have been coated only when constructed after September 15 and scheduled to be opened to traffic before the following April 15. The first winter following construction is generally recognized as the most critical period with respect to the resistance of concrete pavement to chloride salt scaling.

At the beginning of the bridge deck linseed oil treatment program, questions were raised as to the length of time that the treatment could be expected to remain effective and as to what intervals of retreatment and rates of application would be required if the treatment was found to provide only temporary protection.

The study with which this report is concerned was undertaken in 1962 in an effort to answer the questions being asked. Bridge decks well distributed throughout the State and representing a range of ages and traffic conditions were selected for the study.

The severe spalling that has been noted over reinforcement bars in certain bridge decks in more recent years in Illinois and elsewhere and which has been attributed to steel corrosion was not recognized as being of major consequence when the present study was undertaken in 1962. The bridges selected for this study have been relatively free of spall, and this study has furnished no information regarding the value of the linseed oil treatment in the control of spall.

STUDY PROCEDURE

Typical bridge decks treated in 1962 with the linseed oil solution were selected from each of the ten highway districts into which the State was then divided for inclusion in the study. A map showing district boundaries and average annual snowfall depths is shown in Figure 2. The snowfall depths are deceptive with respect to the frequency of occurrence of conditions requiring application of deicing agents. During the period of the study, an average of 24 applications per winter were required in the northern part of the State on the rural Interstate and primary systems, 32 in the central part, and 37 in the southern portion. Fewer applications were made on the secondary system of highways. In District 10 (Chicago) the number of salt applications per storm was usually significantly greater than in the downstate districts.

The bridge decks selected for study were divided into four groups to meet the following criteria:

Group	Age at Initial Treatment in 1962	Traffic Condition	Chloride Salt Application
1	New	Relatively high volume	Frequent
2	5 years	Relatively high volume	Frequent
3	10 years	Relatively high volume	Frequent
4	New	Low volume	Seldom

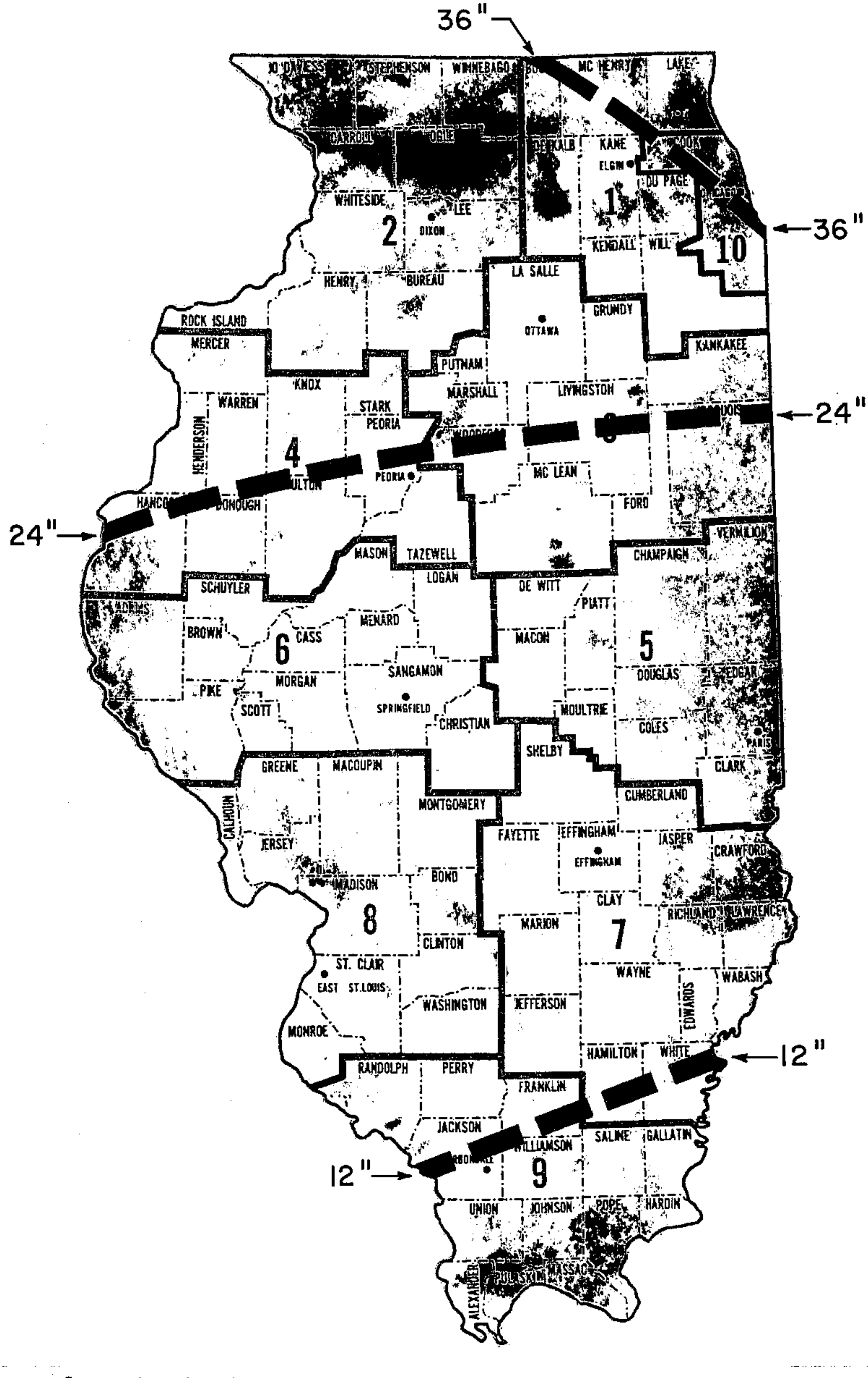

Figure 2. District boundaries and lines of mean annual total snowfall

One set of decks in each group was retreated in 1964, another in 1965, another in 1966, and another in 1967. The fifth set in each group was retreated at the end of the period of study, which was concluded in 1968. Each set included from five to eight decks. A total of 141 decks selected at the beginning were available for the full study. Several of the decks originally selected were resurfaced during the course of the investigation.

Each bridge deck in the study was inspected annually (except for a few inadvertent omissions) during the period of 1962 through 1968 to assess the quantity of scale present and its severity. Since the treatments were applied to handrails, curbs, and walkways in addition to the deck portion reserved for vehicular travel, these were also included in the surveys.

Observed scaling was placed in the following four severity classes:

Scale Class	Description
1	Pitting with some peeling of surface mortar
2	Peeling of mortar to expose about 1/4-inch depth of coarse aggregate
3	Scaling of mortar to expose more than 1/4-inch depth of coarse aggregate; remaining concrete sound
4	Scaling well into concrete with loosened pieces of coarse aggregate

The area of scale observed in the field surveys was recorded as a percent of the total area of the deck item involved (area of vehicular travel, area of walkway, etc.).

Estimates were made each year of the number and quantity of deicent applications. This was done separately for the rock salt and calcium chloride applications. Only minor quantities of the latter were used.

LINSEED OIL APPLICATIONS

The initial treatment of all bridge decks in 1962 consisted of two applications of 0.02 gallons per square yard each of 50:50 by volume mixture of boiled linseed oil and petroleum spirits.

The planned retreatments consisted of 0.015 gallons per square yard of solution for the half of each bridge deck east or south of the longitudinal centerline (including walkway, etc.), and 0.025 gallons per square yard for the half west or north of the longitudinal centerline. In many instances less than the planned 0.025 gallons per square yard was used because of slow absorption into the concrete. The retreatments were made under traffic by temporary lane closures of from two to six hours with the usual drying time being about three hours. Before reopening retreated lanes, any linseed oil remaining on the surface was blotted with sand.

Applications of the protective solution were made with weed spray units mounted on trucks. The equipment included tanks ranging from 150 to 300 gallons capacity, a pressure pump, a pressure regulator, and pressure relief controls. Spray bars were equipped with nozzles to produce a series of fan-shaped sprays to cover the surface to be treated in one pass. Truck speeds of four to six miles per hour produced the intended rate of application. Both tachometers and low-speed speedometers were used at various times to control the rate of application following calibration with a stop watch. Walkways, handrails, and other portions of the structures requiring treatment were coated manually with wand-type hand units.

The cost of the retreatment applications, covering materials and labor and including labor required for traffic control, averaged between $0.11 and $0.12 per square yard coated.

EVALUATION

A weighting system was devised to convert extent and class of scaling to a numerical index indicative of the average condition of the deck as regards scaling. This numerical index was called the scale rating. It was derived by assigning the weight of 0.25, 0.50, 0.75, and 1.00 to recorded percentage quantities of class 1, 2, 3, and 4 scale, respectively, as defined earlier. Therefore, the possible scale index of a deck could range from 0 for the condition of no scale to 100 for the condition of 100 percent class 4 scale. This rating index, although arbitrary, allowed averaging within groups and comparisons between groups.

The scaling progression data collected annually from the study bridges which were retreated with linseed oil mixture at time intervals of from two to five years after initial treatment in 1962 indicate that, although the initial treatment generally served to delay the onset of scaling, the retreatments have not been significantly reliable in preventing continued scaling of the surface mortar or in preventing deeper deterioration of the decks. Many of the structures retained their sound condition of 0 scale rating without retreatment for six years while others have developed scaling even though they were retreated. Many older bridges have experienced heavier scaling than bridges of Interstate construction.

Generally, the safety walks and hubguards have had heavier scaling than the decks. Also, most of the deck scaling is concentrated in the gutter areas.

The heavier scaling outside the driving lanes of the deck might be attributable to salt concentration from deicing chemicals or to the construction procedure differences in building these portions of the bridges. However, the hubguards and safety walks of the bridges that were initially treated when new and retreated within five years have had little distress. Therefore, it appears that the linseed oil mixture treatments are providing valuable protection for these problem portions of the structures.

It is recognized that many extraneous conditions other than the time interval contribute to the variability of surface scale development. Among these are the variations in air entrainment within and between decks, surface porosity, and other durability factors. Scaling due to reactive aggregates such as reported on Interstate bridges in Virginia[3] has not been reported in Illinois.

Information in Table 1 and Appendix A shows that less scaling developed during the first six years on the rural Interstate and primary system bridges of Group 1 that were initially treated with linseed oil mixture when constructed in 1962 than had developed on the corresponding Group 2 bridges during their first five years of service and before initial treatment in 1962. Only 9 of the 29 rural bridges in Group 1 scaled at all during the study. This apparent control of scaling by the initial treatment on new bridges resulted even with the three-fold increase in deicing salt usage during the study (Figure 1). Undoubtedly some credit must be given to the higher entrained air content requirement (4 to 6 percent) for the decks

3. M. A. Ozol and H. H. Newton, Jr., Joint Report - "Concrete Durability Studies" and "Potentially Reactive Carbonate Aggregates," VHRC 70-742 (1971).

TABLE 1

SCALE RATING PROGRESSION

YEAR OF SURVEY AND SCALE RATING

	Downstate						Cook County		
	1962		1967		1968		1962	1967	1968
Year of Retreatment	Range of Scale Rating	Avg. Scale Rating	Range of Scale Rating	Avg. Scale Rating	Range of Scale Rating	Avg. Scale Rating	Ave. Scale Rating	Avg. Scale Rating	Avg. Scale Rating
Group 1 (New)									
1964	0	0	0 - .05	.02	0 - .08	.02	0	6.08	7.00
1965	0	0	0 - .10	.03	0 - .10	.03	0	4.25	5.00
1966	0	0	0 - .05	.01	0 - .05	.01	0	4.33	5.00
1967	0	0	0 - .75	.18	0 - 1.00	.28	0	6.75	8.00
None	0	0	0 - .02	0	0 - .05	.01	0	7.50	8.50
Group 2 (Five Years Old)									
1964	0- .25	.06	.06- .90	.38	.06- 2.50	.78	Resurfaced		
1965	0-2.00	.39	0 - 2.00	.83	0 - 2.00	.84	1.00	3.25	4.00
1966	0- .25	.07	0 - 1.75	.81	0 - 2.00	.95	1.00	4.00	5.00
1967	0- .25	.05	0 - 1.25	.49	0 - 6.73	1.47	1.00	3.00	4.00
None	0- .72	.12	0 - 1.75	.81	.02- 6.70	2.22	Resurfaced		

Group 3 (Ten Years Old)											
1964	0- .75	.31	0	-10.75	3.33	0	-13.50	4.02	2.00	4.50	5.00
1965	0-1.25	.23	0	- 4.75	1.20	0	- 6.00	1.80	2.00	3.75	4.10
1966	0- .25	.10	0	- 2.75	1.01	0	- 6.25	1.86	2.00	3.30	3.60
1967	0-4.00	.72	0	- 6.25	1.67	0	- 8.00	2.02	8.00	22.50	25.40
None	0-1.00	.31	0	- 2.75	.99	0	- 2.75	1.05	3.00	8.75	9.90
Group 4 (New - Low Traffic Volume)											
1964	0	0	0	- .75	.15	0	- 1.00	.20	0	3.50	6.00
1965	0	0	0	- 1.25	.35	0	- 1.25	.35	0	Resurfaced	
1966	0	0	0	- .75	.22	0	- .75	.37	0	.52	1.00
1967	0	0	0	- 2.00	.55	0	- 2.00	.64	0	.50	1.00
None	0	0	0	- 2.00	.86	0	- 3.50	1.23	0	.50	1.00

constructed in 1962 as opposed to the 3 to 5 percent entrained air requirement in the Group 2 bridges. Also, for the Group 1 bridges it was required that the air content be checked on each load of concrete before being placed into the deck. However, since half of the total bridges in both groups were in the common 4 to 5 percent range it is doubtful that the differences in performance between the groups can be explained completely by differences in entrained air content alone.

Also as shown in Table 1, by 1968 scale ratings did not exceed 1.00 on any of the downstate bridges that were new when initially treated in 1962 (Group 1). However, by 1968 the Group 1 bridges in Cook County (Chicago area) had scale ratings which ranged from 5.00 to 8.50 depending upon year of retreatment. The significantly more extensive scaling of the Cook County (District 10 Urban) bridges reflects the salting practices followed in that district. Whereas the total salt applied per season in the rural districts varied only between 2 and 5 pounds per square yard for the 1962-63 through 1967-68 seasons, the District 10 usage was from 10-15 pounds per square yard.

Concerning the progression of scaling during the investigation, Table 1 shows that the average increase in scaling on rural Group 2 bridges (five years old when first treated) was significantly greater than that on the rural Group 1 (new) bridges. Likewise, the average increase in scaling on the rural Group 3 bridges (10 years old when first treated) was greater than on either the Group 1 or Group 2 bridges. The slopes of the curves in Figure 3 show this graphically. It should be noted that the Group 1 bridges were built with a specified air content of 4-6 percent, and that the Group 2 and Group 3 bridges were built with a specified air content of 3-5 percent.

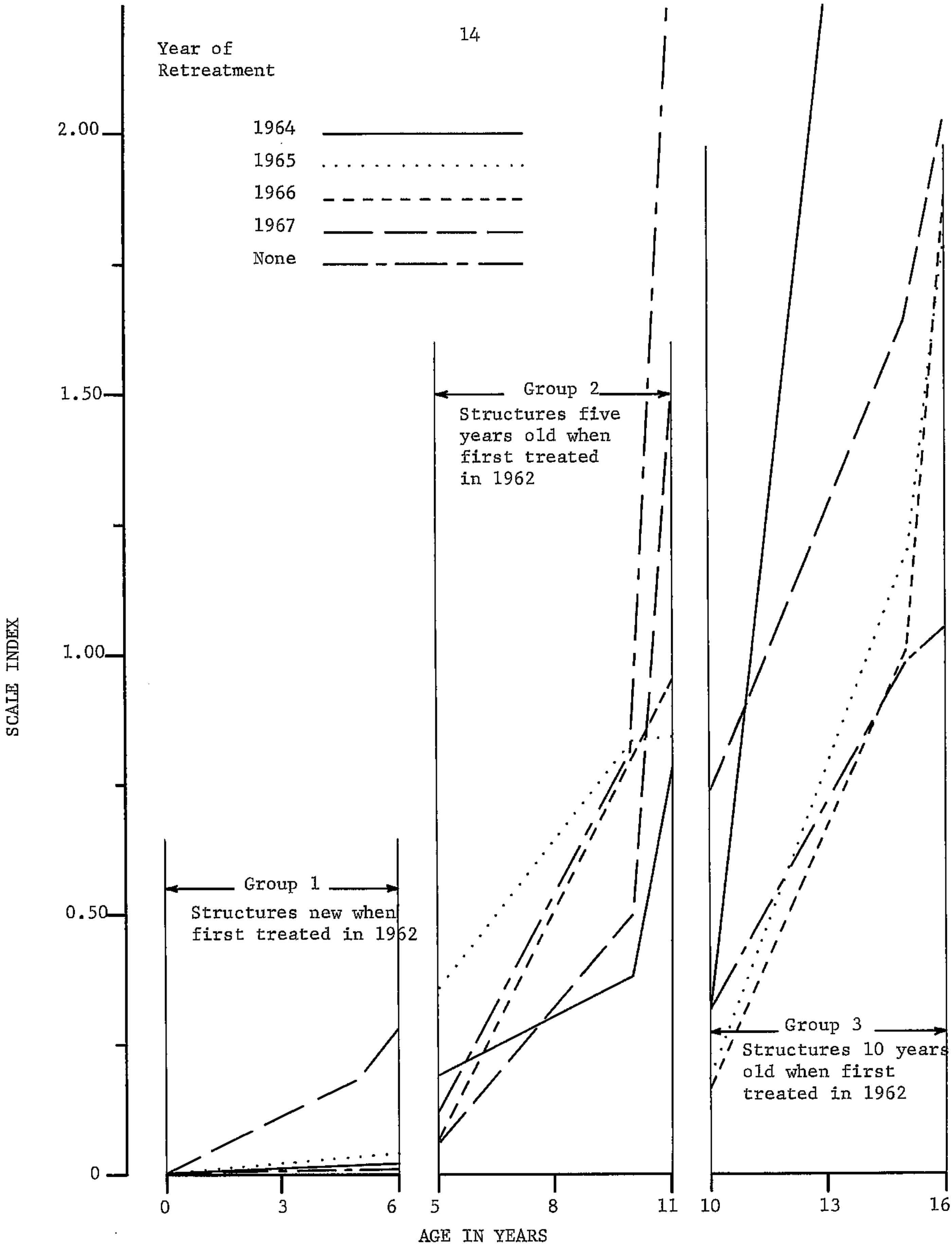

Figure 3. Average scale progression.

Notwithstanding the fact that on the average the scaling on Group 2 and Group 3 bridges increased significantly during the investigation, some went through the entire period with a 0 scale rating.

The Group 4 bridges (new, low volume traffic, and infrequent salt exposure) scaled more rapidly on the average than the rural Group 1 bridges. The reason for this is not known, but it may be that the low volumes of traffic on these bridges did not remove the salt as rapidly as on the main-line bridges. Also, the level of cleanliness is generally lower on these bridges; therefore, there was more debris in the gutter area to catch and hold salt. As was the case with Groups 1, 2 and 3, some Group 4 bridges maintained a 0 scale rating throughout the investigation. Group 4 was unique in that, during the period of study, the scaling reported in Cook County was not significantly greater than that reported downstate.

The average condition of all groups at the time of retreatment is shown in Figure 4. Although the curves in Figure 4 are not entirely consistent, they indicate a general acceleration of scaling of treated decks after about 4 years (after 1966). This is particularly true of rural bridges. Table 2 shows the maximum scale ratings attained during the investigation for all groups.

TABLE 2

MAXIMUM SCALE INDEXES

GROUP	RURAL	URBAN
1	1.00	8.50
2	6.73	5.00
3	13.50	25.40
4	3.50	6.00

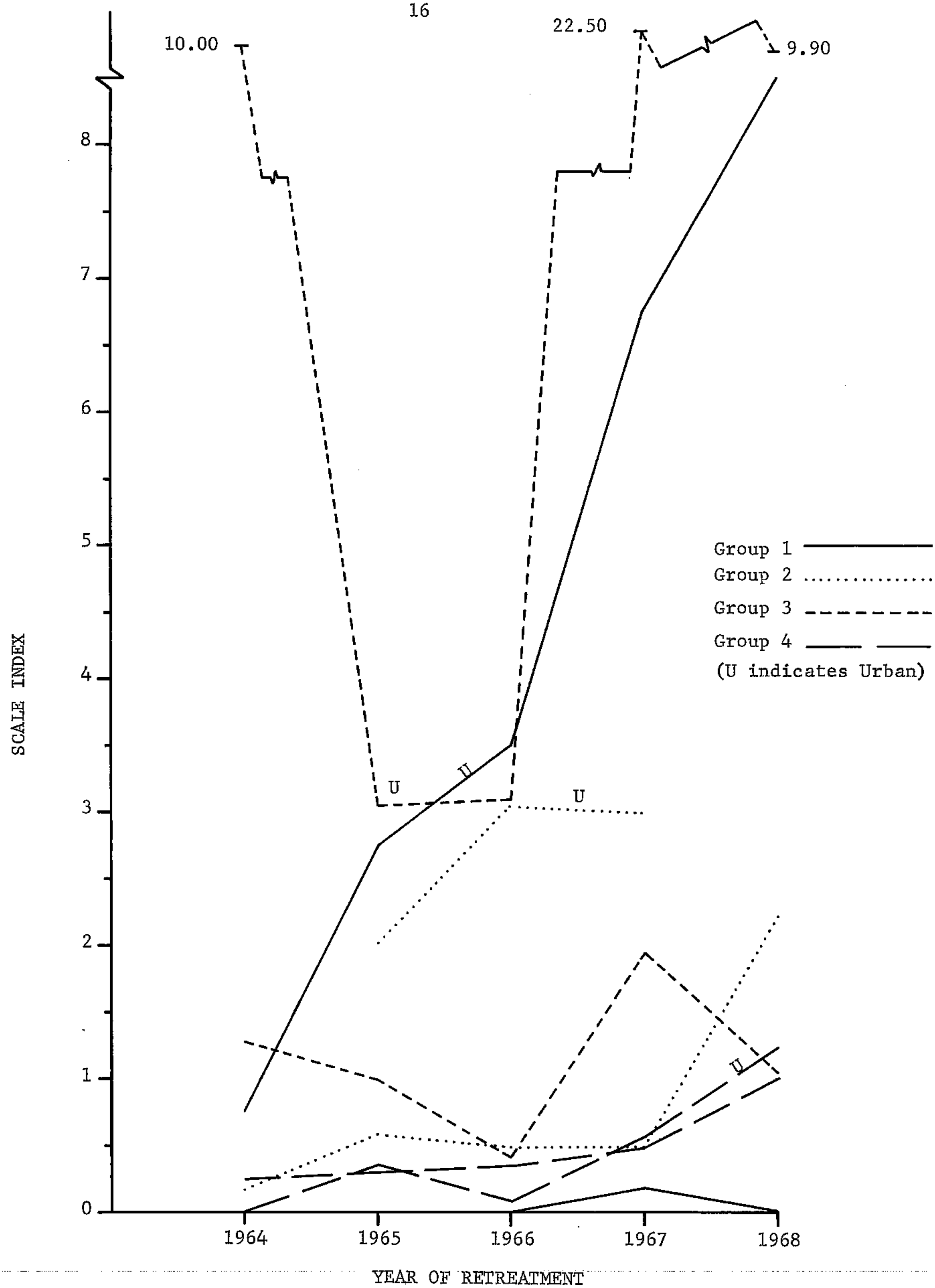

Figure 4. Average scale index at time of retreatment

All Districts throughout the State reported some actual retreatment application rates lower than the planned trial rates of 0.015 and 0.025. The rates of retreatment reported indicate differences in individual decks - heavier rates were absorbed by the more porous concrete. No correlation was found between the rate of retreatment and the resulting protection provided.

The reason for the apparent lack of uniformity in the protection provided by linseed oil treatments is not entirely clear. Undoubtedly the variability in the level of entrained air and the age and condition at the deck at time of initial treatment are principal factors. The effectiveness of a linseed oil treatment appears to be a function of the condition of the deck at the time of treatment - the better the condition, the more effective the treatment. Conversely the poorer the condition of the deck at the time of treatment, the less effective the treatment and the more rapid the progression of scaling already started. The progression of scaling tends to be exponential, once started. Preventive treatments appear to be more productive than treatments done after scaling has begun. Lack of uniformity notwithstanding, the amount of scaling observed on the test bridges during the investigation was small.

The consideration of bridge deck deterioration due to corrosion of reinforcing steel was not included in this study. However, a number of decks were lost to the study because extensive patching and overlayment was required even though the amount of scaling was small. The apparent unreliability of the retreatment of bridge decks with linseed oil in preventing corrosion of the reinforcing steel has led to the current policy of topping all new bridge decks and all existing bridge decks requiring extensive repairs (if the structure will stand the additional dead load) with a waterproofing system consisting of a coal tar-fiber glass interlayer membrane protected by a bituminous concrete surfacing. The interlayer system is much more expensive than linseed oil treatment; however, it provides positive protection and is applied before the bridge is opened to traffic. The policy of providing greater protection was first adopted in 1967 on structures with traffic volumes in excess of 1800 commercial vehicles per day when it became apparent that many of these bridges, especially those in Cook County, were not being sufficiently protected by the linseed oil treatment from serious spalling and corrosion of the reinforcing steel.

CONCLUSIONS AND RECOMMENDATIONS

The scaling reported during the progress of this study was extremely variable, but it was also very light. No bridge that was new at the time of initial treatment in 1962 attained a scale index exceeding 8.50 during the course of the investigation, regardless of location. Only two bridges (out of 141) in the study attained scale indexes exceeding 10 during the course of the investigation, and both of those were ten years old at the time of initial treatment. From this it is concluded that scaling of bridge decks is not a serious problem in Illinois.

The scaling observed on rural Group 1 bridges during the course of the study was less than that developed on the rural Group 2 bridges in the five years preceding the study or on the Group 3 bridges in the ten years preceding the study. Only nine of 29 rural Group 1 bridges scaled at all during the study. This was in spite of a three-fold increase in the use of deicing salts after the initial treatment in 1962. From this it is inferred that the onset of scaling can be delayed by linseed oil treatments.

Group 3 bridges had higher scale indexes at the start of the investigation than did the Group 2 bridges. Likewise, during the study, the increase in scale indexes was greater for the Group 3 bridges than for the Group 2 bridges. The Group 1 bridges, all of which had a scale index of 0 at the start of the study, showed the least increase in scale index during the study. From this it is concluded that linseed oil treatments are more effective in delaying the onset of scaling than in controlling scaling once started.

Actual retreatment rates often were less than the planned 0.025 gallons per square yard because of slow absorption into the concrete. The usual drying time allowed was about three hours. No correlation between rate of retreatment and resulting protection was found. For this reason it appears to be practical to retreat at an application rate such that the material will be absorbed in approximately three hours. Based upon experience to date, this rate usually will be less than 0.025 gallons per square yard.

The extent of scaling during the first four years after initial treatment was minor except for urban bridges in Group 3, and, in general, the rate of scale development was low. After 4 years the extent of scaling increased at an increasing rate. From this it is concluded that the retreatment interval should not exceed 4 years.

IMPLEMENTATION

Based upon all the above it is recommended that the Department's policy of retreatment at 4-year intervals, under which approximately 1000 bridges per year have been retreated since 1964, be continued.

The application rate for the linseed oil mixture on those decks which have not been covered with a waterproofing membrane and bituminous wearing surface should be 0.025 gallons per square yard or that amount which can be absorbed in approximately three hours. Non wearing surfaces such as hubguards and safety walks which are subject to exposure to deicing salts should receive 0.025 gallons per square yard at the same 4-year retreatment interval.

APPENDIX

SCALE RATINGS OF ALL BRIDGES

GROUP 1 - NEW BRIDGES (1962) ON INTERSTATE AND PRIMARY HIGHWAYS

	Retreatment		Scale Rating						
Bridge	Dist.	Year	1962	1963	1964	1965	1966	1967	1968
1	1	1966	0	0	0	0	0	0	0
2		1967	0	0	0.10	0.30	0.50	0.75	1.00
3	2	1964	0	0	0	0	0	0	0
4		1965	0	0	0	0	0	0	0
5		1966	0	0	0	0	0	0	0
6		1967	0	0	0	0	0	0	0
7		1968	0	0	0	0	0	0	0
8	4	1964	0	0	0	0	0	0	0
9		1965	0	0	0	0	0	0	0
10		1966	0	0	0	0	0	0	0
11		1967	0	0	0	0	0	0	0
12		1968	0	0	0	0	0	0	0
13	5	1964	0	0	0	0	0	0	0
14		1965	0	0	0	0	0	0	0
15		1966	0	0	0	0	0	0	0
16		1967	0	0	0	0	0	0	0
17		1968	0	0	0	0	0	0	0
18	6	1964	0	0	0.02	.02	.02	.05	0.08
19		1965	0	0	0	.08	.08	.10	0.10
20		1966	0	0	0.02	.08	.02	.05	0.05
21		1967	0	0	0.02	.02	.02	.05	0.40
22		1968	0	0	0.02	.02	.05	.02	0.05
23	7	1964	0	0	0	0	0	.05	0.05
24		1965	0	0	0	0	0	0.08	0.08
25	9	1964	0	0	0	0	0	0	0
26		1965	0	0	0	0	0	0	0
27		1966	0	0	0	0	0	0	0
28		1967	0	0	0	0	0.25	0.25	0.25
29		1968	0	0	0	0	0	0	0
30	10	1964	0	0	0.75	2.25	4.30	6.08	7.00
31		1965	0	0.80	2.00	2.75	3.50	4.25	5.00
32		1966	0	0.75	2.00	2.80	3.50	4.33	5.00
33		1967	0	1.30	2.75	4.15	5.50	6.75	8.00
34		1968	0	1.85	3.60	5.15	6.35	7.50	8.50

GROUP 2 - FIVE-YEAR-OLD BRIDGES (1962) ON INTERSTATE AND PRIMARY HIGHWAYS

	Retreatment		Scale Rating						
Bridge	Dist.	Year	1962	1963	1964	1965	1966	1967	1968
35	1	1966	0.10	0.25	0.50	0.80	1.25	1.50	2.00
36		1967	0	0	0.10	0.20	0.35	0.50	0.75
37		1968	0	0	0.15	0.35	0.65	0.75	0.78
38	2	1964	0	0	0	0.06	0.06	0.06	.06
39		1965	0	0	0.75	0.75	0.75	0.75	.75
40		1966	0	0	0	0	0	0.06	.06
41		1967	0	0	0	0.12	0.19	0.25	.30
42		1968	0	0	0.25	0.25	0.38	0.50	.60
43	4	1964	0.25	0.25	0.25	0.25	0.25	0.25	.25
44		1965	0.25	0.25	0.25	0.25	0.25	0.25	.25
45		1966	0	0	0	0	0	0	0
46		1967	0	0	0	0	0	0	0
47		1968	0.72	2.38	0.72	0.72	0.72	0.72	0.72
48	5	1964	0	0	0	0	0.50	0.50	2.50
49		1965	2.00	2.50	1.50	2.00	2.00	2.00	2.00
50		1966	0.25	0.25	0	0	0	1.25	1.75
51		1967	0.25	0.25	0	0	0	1.25	1.75
52		1968	0	0	0.25	0.25	0.25	1.75	4.75
53	6	1964	0.12	0.12	0.75	0.30	0.50	0.90	1.20
54		1965	0.12	0.12	0.30	0.30	0.72	1.70	1.78
55		1966	0.12	0.12	0.62	0.80	1.17	1.10	1.10
56		1967	0.12	0.12	0.28	0.25	0.28	0.70	6.73
57		1968	0.12	0.62	0.12	0.22	0.22	0.70	6.70
58	7	1964	0	0	0	0	0	.08	0.15
59		1965	0	0	0	0	0	0	0
60		1966	0	0	0	0	0	0	0
61		1967	0	0	0	0	0	0	0
62		1968	0	0	0	0	0	0	0.02
63	9	1964	0	0	0	0.50	0.50	0.50	0.50
64		1965	0	0	0.25	0.25	0.25	0.25	0.25
65		1966	0	0	0	0.25	0.50	1.75	1.75
66		1967	0		0.25	0.25		0.75	0.75
67		1968	0	0	0	0.25	0.25	1.25	2.00
68	10	1965	1.00	1.20	1.50	2.00	2.65	3.25	4.00
69		1966	1.00	1.30	1.75	2.25	3.05	4.00	5.00
70		1967	1.00	1.10	1.25	1.50	2.10	3.00	4.00

GROUP 3 - TEN-YEAR-OLD BRIDGES (1962) ON PRIMARY HIGHWAYS

	Retreatment		Scale Rating						
Bridge	Dist.	Year	1962	1963	1964	1965	1966	1967	1968
71	1	1967	4.00	5.00	5.45	5.60	5.75	6.25	8.00
72		1968	0.25	0.28	0.31	0.35	0.40	0.45	0.58
73	2	1964	0	0	.12	.12	.19	.38	0.50
74		1965	0	0	0	0	0	.06	0.10
75		1966	0	0	.12	.12	.12	.31	0.45
76		1967	0	0	0	.06	.06	0.06	0.06
77		1968	0	0	.88	.88	.94	1.00	1.25
78	4	1964	.62	.62	0.68	0.62	0.62	.62	.62
79		1965	0	.25	0	0	0	0	0
80		1966	.12	2.50	.12	0.12	0.12	.12	.12
81		1967	0	0	0	0	0	0	0
82		1968	1.00	4.75	1.25	1.25	1.25	1.25	1.25
83	5	1964	0.75	.75	.75	0	0	1.00	1.00
84		1965	1.25	1.25	1.25	1.25	1.25	2.25	4.50
85		1966	.25	.25	.25	.25	.25	1.25	3.25
86		1967	.75	.75	1.25	1.25	1.25	2.25	3.00
87		1968	.75	.75	.75	0	0	1.00	1.00
88	6	1964	.50	1.00	3.12	3.12	7.00	10.75	13.50
89		1965	.12	.12	.12	.12	.15	.12	0.20
90		1966	.25	.25	.25	.25	.52	1.62	1.10
91		1967	.30	.50	.82	.82	1.32	2.35	2.35
92		1968	.15	.25	.35	.35	.35	.45	0.52
93	7	1964	0	0	0	0	0	0	0
94		1965	0	0	0	0	0	0	0
95		1966	0	0	0	0	0	0	0.01
96		1967	0	0	0	0	0	0	0
97		1968	0	0	0	0	0	0	0
98	9	1964	0	2.50	3.00	5.25	5.50	7.25	8.50
99		1965	0	2.50	2.00	4.75	3.75	4.75	6.00
100		1966	0	1.00	.75	1.50	1.50	2.75	6.25
101		1967	0	0	0.50	0.75	0.75	0.75	0.75
102		1968	0	1.00	1.00	1.75	2.00	2.75	2.75
103	10	1964	2.00	9.25	10.00	4.00	4.10	4.50	5.00
104		1965	2.00	2.35	2.70	3.05	3.40	3.75	4.10
105		1966	2.00	2.25	2.55	2.80	3.10	3.30	3.60
106		1967	8.00	10.90	13.80	16.70	18.65	22.50	25.40
107		1968	3.00	4.15	5.30	6.45	7.80	8.75	9.90

GROUP 4 - NEW BRIDGES (1962) ON SECONDARY HIGHWAYS

	Retreatment		Scale Rating						
Bridge	Dist.	Year	1962	1963	1964	1965	1966	1967	1968
108	1	1967	0	0.25	0.25	0.25	0.25	0.25	0.25
109		1968	0	0.75	0.75	0.75	0.75	0.75	0.75
110	2	1964	0	0	0	0.25	0.50	0.75	1.00
111		1965	0	0	0.25	0.50	0.25	0.50	0.50
112		1966	0	0	0	0.12	0.38	0.50	0.75
113		1967	0	0	0.25	0.25	0.38	0.50	0.75
114		1968	0	0	0	0.12	0.19	0.25	0.30
115	4	1964	0	0	0	0	0	0	0
116		1965	0	0	0	0	0	0	0
117		1966	0	0	0	0	0	0	0
118		1967	0	0.06	0.12	0.25	0.25	0.35	0.50
119		1968	0	0	0	0.12	1.25	2.00	3.00
120	5	1964	0	0	0	0	0	0	0
121		1965	0	0	0	0	0	0	0
122		1966	0	0	0	0	0	0	0
123		1967	0	0	0	0	0	0	0
124		1968	0	0	0	0	0	0	0
125	6	1966	0	0	0.02	0.08	0.08	0.08	0.72
126		1967	0	0.12	0.18	0.28	0.45	0.75	0.95
127		1968	0	1.75	1.08	1.48	0.40	1.05	1.05
128	7	1964	0	0	0	0	0	0	0
129		1965	0	0	0	0	0	0	0
130		1966	0	0	0	0	0	0	0
131		1967	0	0	0	0	0	0	0
132		1968	0	0	0	0	0	0	0
133	9	1964	0	0	0	0	0	0	0
134		1965	0	0.50	1.25	1.25	1.25	1.25	1.25
135		1966	0	0	0	0	0	0.75	0.75
136		1967	0	0.25	1.00	1.00	1.00	2.00	2.00
137		1968	0	0.25	0.50	0.75	1.00	2.00	
138	10	1964	0	0.10	0.25	0.50	1.75	3.50	6.00
139		1966	0	0.15	0.20	0.30	0.35	0.52	1.00
140		1967	0	0.10	0.15	0.25	0.30	0.50	1.00
141		1968	0	0.10	0.15	0.25	0.30	0.50	1.00