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"EXPERIMENTAL CONCRETE PAVEMENT TINING,

ROUTE I-295, Section 1X

by

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16. Abstract

This report describes the results of a field investigation undertaken to develop improved procedures for texturing (tining) concrete pavements. The investigation included both hand and machine tining and was carried out on Route I-295, Section 1X.

The use of some rather simple and inexpensive equipment modifications, coupled with greater attention to proper construction practices, resulted in significantly improved tining results.

A revised tining specification reflecting the improved practices described in this report is presented.

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1.0 INTRODUCTION

This report describes the results of a field investigation undertaken to develop improved procedures for texturing (tining) concrete pavements. The investigation included both hand tining (currently used on bridge approach slabs) and machine tining (used on mainline pavement). The work was carried out on Route I-295, Section 1X during July thru September 1987.

2.0 PROBLEM STATEMENT / OBJECTIVE

Earlier studies (1) have suggested that the texture depth achieved on the Department's concrete pavement projects is highly variable and frequently does not meet specifications. In addition, the appearance of the finished surface is often less than desired due to tearing and dragging of the aggregates.

Research by others has confirmed that achieving a proper as-constructed texture depth is very important in providing adequate skid resistance throughout the life of the pavement, with small differences (1/16") in average texture depth apparently playing a significant role in the life of the texture (2).

This investigation was undertaken to determine if the appearance and mean tine depth on Department projects could be improved through certain modifications to the tining equipment and construction practices.

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(1) Diringer, K. and Quinn, J. "Texturing Bridge Decks-- A Final Report", NJDOT Research Report 86-009 (April 1986).

(2) Grady, J. " Decay Of Tine- Textured Grooves In Rigid Pavements" NYDOT Research Report 83-107 (September 83)

3.0 BACKGROUND

The Department's specifications require the following as-constructed dimensions for the tined texture:

Spacing: 1/2 to 3/4"

Depth: 1/8 to 3/16"

Width: 0.10 to 0.125"

The equipment condition and the construction procedures initially observed on the Section 1X project were as follows:

1. Condition of tining rake: The rake mounted on the tining machine had bent, crooked and missing tines. Concrete adhered to some tines, distorting their dimensions. These conditions contributed to uneven spacing and uneven depth of the grooves and caused the surface to appear ragged and unworkmanlike. In addition, the tines appeared to be too flexible to penetrate deep enough to obtain the specified depth.

2. Tining machine speed: The tining speed seemed to be to high to control the penetration and the aggregate dragging in the wet concrete. Also, due to the lack of stiffness of the tines, texturing was begun prematurely (i.e., when the fresh concrete was too plastic to retain the impression of the tines).

4.0 NATURE OF THE EXPERIMENT

Several modifications of the equipment and construction practices were investigated to increase the mean tine depth. Those modifications included the following:

1. Equipment modification: The "flimsy" rake was replaced by a stiffer tine rake. The thickness of this spring steel rake

was 0.0375" and the width was 0.11". Every alternate tine of the 1/2" spaced rake was bent upwards to increase the spacing of the tines from the original 1/2" to 1".

2. Construction practices modifications: In order to produce an improved texture in the fresh concrete surface, the waiting time prior to commencing the tining operation was extended. The time at which the tining is done is critical and is affected by many factors, including the slump of the concrete and weather conditions (temperature, wind). The presence of an expereienced, conscientious inspector is critical to the selection of the appropriate time to tine.

The tining machine speed was reduced to 2 feet/second. This slower speed permitted much better penetration in the fresh concrete.

The modifications described above were implemented on slabs 1595 to 1609 (machine tining) and slabs 1663 to 1668 (hand tining).

5.0 DESIGN OF THE EXPERIMENT AND TEST SECTION LAYOUT

Two basic experimental variations were investigated. These variations consisted of comparing the results of a 1" tining spacing to the standard 1/2" spacing for both machine and hand finishing.

The tine depths at various randomly selected locations on the hardened surface were measured using a tire-tread guage. At each of the selected sites, a 3' square was drawn and 10 readings were taken along the diagonal. The various test sections and their locations are shown in Table 1.

TABLE 1: TEST SECTION DESCRIPTION

Type of Tining	Location (Slab #)	Length	Total Number of Tests
Machine--Experimental	1595-1609 shoulder	1,020'	600
Machine--Control	1577-1594 shoulder	1,224'	300
Hand--Control	1541-1550; 1668-1674 approach slab	1,122'	490
Hand--Experimental	1663-1668 approach slab	374'	160

6.0 ANALYSIS AND RESULTS

The collected data are tabulated in Table 2 and plotted in Figures 1 and 2.

TABLE 2: TINING RESULTS

Type of Tining	Mean Tine Depth (1/32")	Percent of Tests Less Than 1/8" Spec Minimum
MACHINE		
Experimental	6	19
Control	4	26
HAND		
Experimental	5	22
Control	3	63

It is clear from the tabulated and plotted data that the improved eqipment and construction practices in the experimental sections produced better results for both machine and hand finishing.

Figure 1

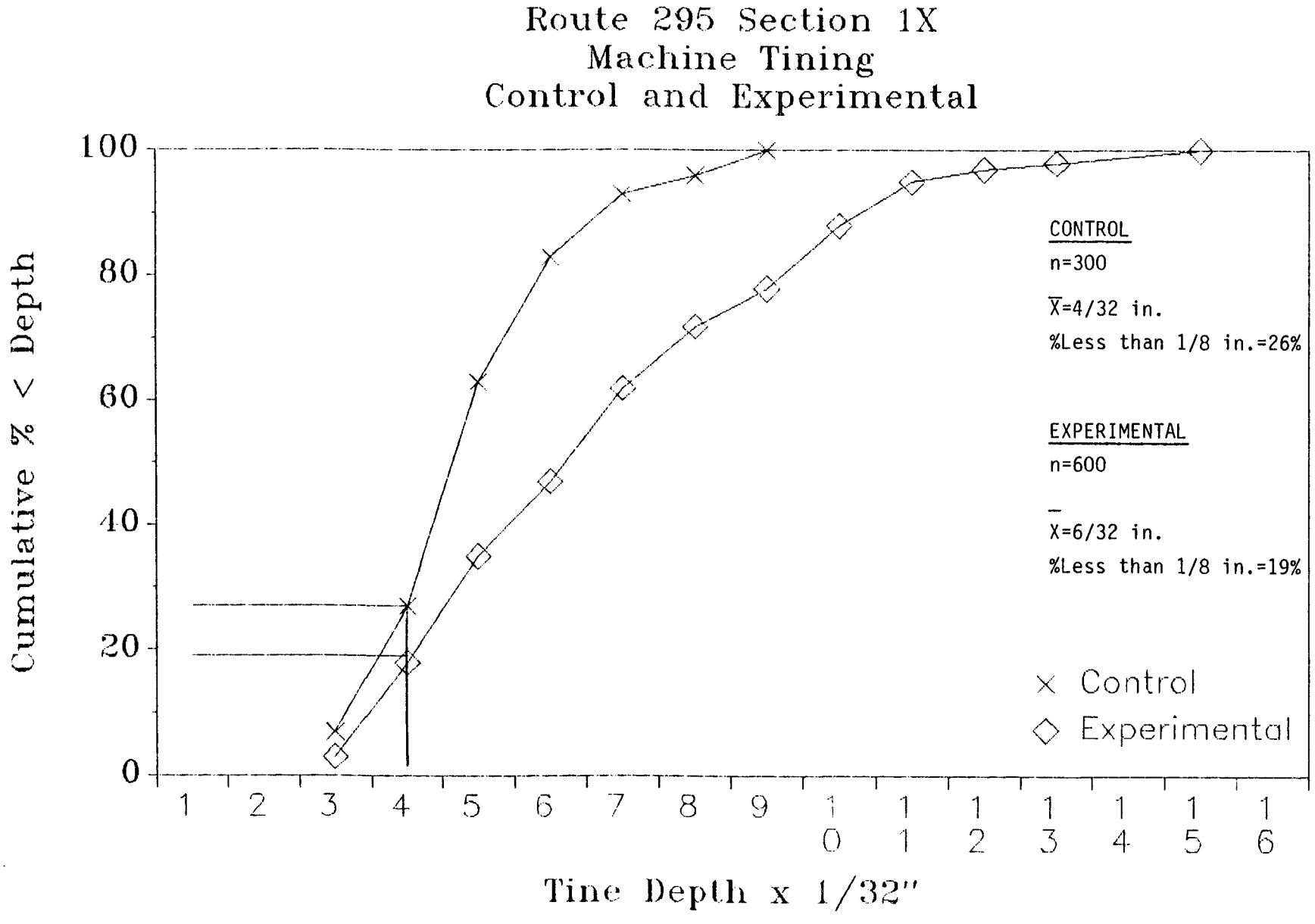
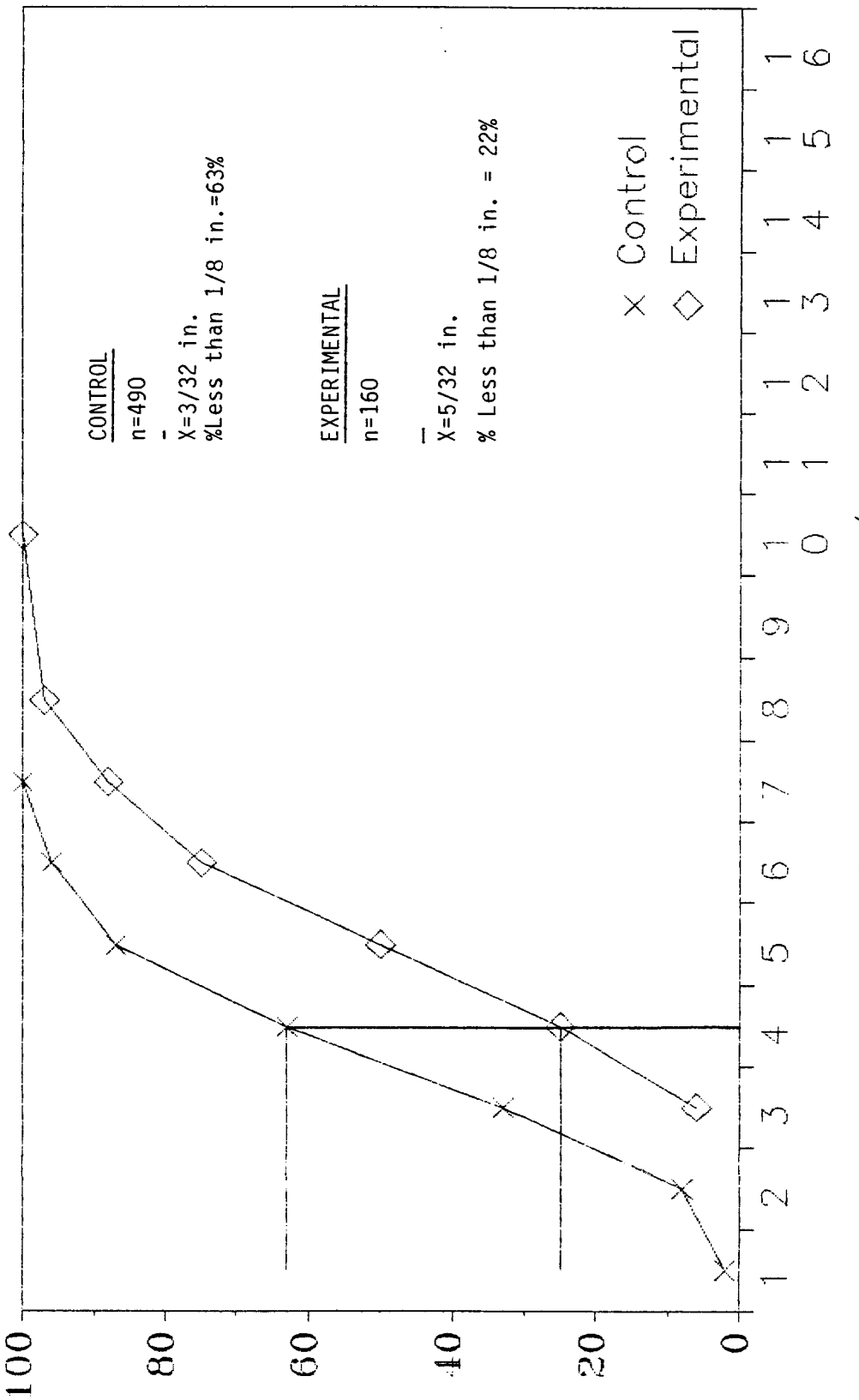

Route 295 Section 1X
Machine Tining
Control and Experimental
Cumulative % < Depth
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Tine Depth x 1/32"
CONTROL
n=300
X=4/32 in.
%Less than 1/8 in.=26%
EXPERIMENTAL
n=600
X=6/32 in.
%Less than 1/8 in.=19%
× Control
◇ Experimental

Figure 2

Route 295 Section 1X
Hand Timing
Control and Experimental



The most dramatic improvement was achieved in the hand finishing operation, where the modified equipment and procedures resulted in three times greater compliance with the 1/8" specification minimum. In the case of the machine texturing, a 1/16" increase in average tine depth was achieved and 7% more of the test data complied with the 1/8" minimum.

7.0 CONCLUSIONS

The use of some simple and inexpensive modified equipment and construction practices resulted in a significant improvement in the pavement texturing operation on Route I-295, Section 1X. Those modifications included the following:

1. Increasing the spacing between tines (1" vs. 1/2"),
2. Use of stiffer tines (0.0375" thick x 0.11" wide),
3. Reducing tining rake speed (2 feet/sec maximum),
4. Extending the waiting time to commence tining, and
5. Reducing the overlap of successive tining rake passes (1 to 2" vs. 6 to 9").

8.0 RECOMMENDATIONS

In order to ensure more consistent achievement of acceptable surface texturing results, the Standard Specifications should be modified as follows:

Subsection 405.03 (g) of the Standard Specifications is replaced by the following:

(g) Tines. The metal tines shall be tempered spring steel, arranged in a single line and securely mounted in a suitable head (rake) and shall be 0.0375" thick, 0.11" wide, 6 to 8" long and spaced at 1" centers. The tines shall be capable of producing a groove of the specified dimensions in the plastic concrete without slumping of the edge or tearing of the surface. Tines shall be maintained so as to remain straight, clean and free of any concrete buildup. The metal comb (rake) shall be attached to a mechanical device capable of traversing the entire paving width in a single pass at a uniform speed.

Subsection 405.13 (g) of the Standard Specifications is replaced by the following:

(g) Surface texture. The surface texture shall be a steel tine finish having a uniform pattern of grooves perpendicular to the centerline, spaced at 1.0" ± 0.125"centers, 0.10 ± 0.025"wide, and 0.125 to 0.25" deep. A mechanical comb conforming to Subsection 405.03 shall be used to produce the tine finish. The tine finish for the 12" of concrete surface adjacent to curbs or raised berms may be omitted.

The tine finish shall be applied when the water sheen has practically disappeared. Finishing shall be completed before the concrete is in such condition that the surface will be torn or roughened by the

operation. The finished surface shall be free from rough or porous areas, irregularities or depressions.

The mechanical comb shall be drawn across the concrete surface at a slow, uniform speed not to exceed 2 feet/second. Successive passes of the mechanical comb shall overlap by approximately 1 to 2".

Hand combs with steel tines shall be available at all times for the purpose of providing a surface texture in the event of a breakdown of the mechanical comb. The hand comb shall be drawn from the center to the edge of the concrete at a constant angle with the surface, exerting constant pressure on the plastic concrete to produce the required uniform texture.

Conformance to the required minimum tine depth of 0.125" of the finished concrete surface shall be determined as follows:

Within a lot of approximately 2,000 square yards or less, twenty locations shall be randomly selected. At each of these locations, a square of 3' x 3' shall be marked on the pavement surface. Along the diagonal of the 3' x 3' square, 10 tine depth readings will be taken at approximately equal intervals using a tire tread depth guage. An average tine depth will be computed and recorded for each location. A mean value $(\overline{X})$ and the corresponding sample standard deviation (S) for the lot will be computed.

An acceptable lot shall produce a Quality Index, Q, of 0.15, or greater, where

$$Q = \frac{X - L}{S}$$

X = Sample mean (average for 20 locations), expressed as a decimal to the nearest 0.001 inch

L = Acceptance Limit = 0.125

S = Sample standard deviation, expressed as a decimal to the nearest 0.001 inch.

Should the lot fail to meet the quality index, a retest shall be conducted following the same tine depth measurement procedure on a new sample of 20 randomly selected sites.

If the retest confirms the lot's failure, then the failed lot's surface shall be sawcut groove finished. Sawcutting will not be permitted until the concrete pavement has attained a strength of at least 3000 pounds per square inch as determined from cylinders cast during placement of the concrete pavement or is at least 14 calendar days old. Grooves shall be cut perpendicular, radial or longitudinal to the centerline of the roadway. Grooves shall be rectangular in shape. They shall conform to the following dimensions:

Width ..... .1" to .15"
Depth ..... .25" to .375"

Grooves shall be spaced at 1.5" +/- .0615" center-to-center of groove. This spacing dimension may be increased up to 3" at the end of each pass as necessary. During remedial texturing, the groove dimensions shall be checked at random. If the minimum depth is not achieved, necessary adjustments shall be immediately made.

When sawcutting grooves is required, sawing equipment specifically designed and equipped for the grooving of pavements shall be provided. The saws shall be of a multibladed type, adequate in number of units and power to complete the sawcut grooving operation, equipped with water-cooled, circular, diamond edge blades and alignment wheels. A system of slurry collection shall be provided. An ample supply of replacement saw blades shall be maintained at the work site at all times during grooving operations.