NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION

Experimental Study ND 94-09

Evaluation of Tining Widths to Reduce Noise of Concrete Roadways

Final Report

Project IM-1-094(011)102

November 1997

Prepared by

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. [1]
STATE YEAR NUMBER SUF.
N D 9 4 - 0 9 [ ]

CONSTRUCTION PROJ. NO. [8]
IM-1-094(011)102

LOCATION [28]
Morton County

EVALUATION FUNDING [48]
1 [X] HP&R
2 [ ] CONSTRUCTION
3 [ ] DEMONSTRATION
4 [ ] IMPLEMENTATION

NEEP NO. [49]

PROPRIETARY FEATURE? [51]
[ ] YES
[X] NO

SHORT TITLE

TITLE [52]
Evaluation of Tining Widths to Reduce Noise of Concrete Roadways

THIS FORM

DATE [140]
MO. YR.
1 1 - 9 7

REPORTING [144]
1 [ ] INITIAL
2 [ ] ANNUAL
3 [X] FINAL

KEY WORDS

KEY WORD 1 [145] SAFETY

KEY WORD 2 [167] SKIDRESISTANCE

KEY WORD 3 [189] GROOVING

KEY WORD 4 [211]

UNIQUE WORD [233] TINING

PROPRIETARY FEATURE NAME [255]

CHRONOLOGY

Date Work Plan Approved: MO. YR. [277]	Date Feature Constructed: MO. YR. [281]	Evaluation Scheduled Until: MO. YR. [285]	Evaluation Extended Until: MO. YR. [289]	Date Evaluation Terminated: MO. YR. [293]
0 7 - 9 4	0 8 - 9 4	1 2 - 9 9	-	1 1 - 9 7

QUANTITY AND COST

QUANTITY OF UNITS *(Rounded to whole numbers)* [297]

UNITS [305]
1 [ ] LIN. FT.
2 [ ] S.Y.
3 [ ] S.Y.-IN.
4 [ ] C.Y.
5 [ ] TON
6 [ ] LBS.
7 [ ] EACH
8 [ ] LUMP SUM

UNIT COST *(Dollars, Cents)* [306]

AVAILABLE EVALUATION REPORTS

[X] CONSTRUCTION [315]
[X] PERFORMANCE
[X] FINAL

EVALUATION

CONSTRUCTION PROBLEMS [318]
1 [X] NONE
2 [ ] SLIGHT
3 [ ] MODERATE
4 [ ] SIGNIFICANT
5 [ ] SEVERE

PERFORMANCE [319]
1 [ ] EXCELLENT
2 [ ] GOOD
3 [X] SATISFACTORY
4 [ ] MARGINAL
5 [ ] UNSATISFACTORY

APPLICATION

[320]
1 [X] ADOPTED AS PRIMARY STD.
2 [ ] PERMITTED ALTERNATIVE
3 [ ] ADOPTED CONDITIONALLY
4 [ ] PENDING
5 [ ] REJECTED
6 [ ] NOT CONSTRUCTED

(Explain in Remarks if 3, 4, 5, or 6 is checked)

REMARKS

[321]
No problems with constructing various tining spaced sections. Skid numbers were in the 50's in 1995. No noticeable difference in traffic sound levels from the different tining spacings. In-vehicle noise study indicates that sections with 2" or less tine spacing are a little quieter with randomly spaced tining the best.

NDDOT adopted random spaced tining.

[700]

Experimental Study ND 94-09

Evaluation of Tining Depths to Reduce Noise of Concrete Roadways

FINAL REPORT

Project IM-1-094(011)102

November 1997

Written by

Mike J. Marquart

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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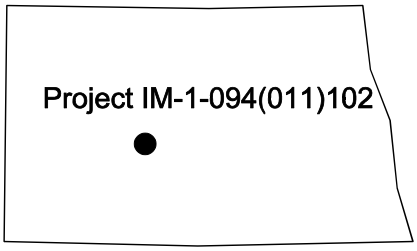
Evaluation of Tining Widths to Reduce Noise of Concrete Roadways

Objective

The primary purpose of roadway surface texturing of pcc pavements is to reduce wet-weather accidents. In recent years the public is asking engineers and contractors to pay attention to pavement smoothness and pavement/tire noise. The object of this experimental project is to evaluate the effectiveness of various tining widths to reduce noise.

Location

The project begins 2.5 miles west of Eagles Nest interchange and continues 13.13 miles to the east of Geck interchange, MP 101.00 to 114.13 Lt. Refer to the project plans found in Appendix A. The experimental tining sections are located between Station 1641+17 and 1802+18 of the westbound lanes. See figure 1 which shows each section location.



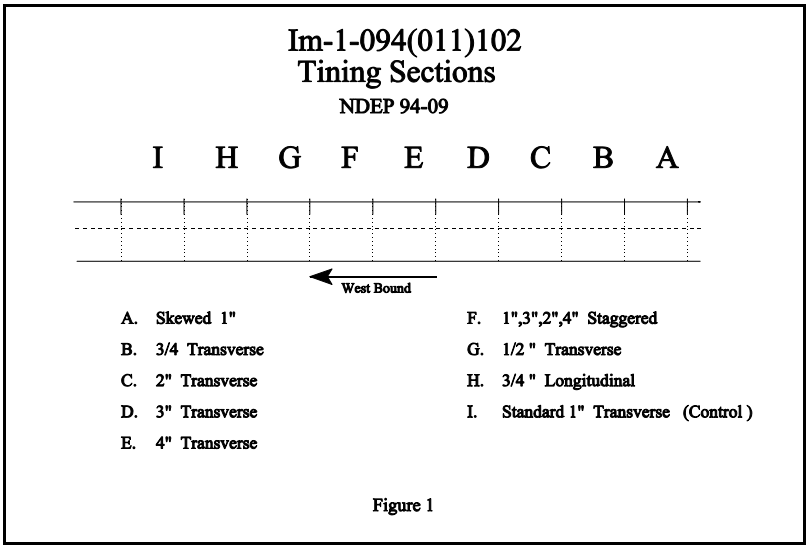


Figure 1

Photo 1 shows the area containing the tining sections. The photo is taken from section B and ends with section I which is the control section. This section is going uphill near the far horizon.

Photo 1. Overview of the tining project

Traffic

Year	Cars	Trucks	Total ADT	Rigid Pvmn't ESAL's
1996	1675	360	2035	430
1997	1560	450	2010	560

Project History

YEAR	DEPTH	TYPE of IMPROVEMENT	WIDTH
1961		Grade	48'
1994	4.0"	Salvaged Base	46'
1994	4.0"	Perm. Cement Stab. Base	44'
1994	9.0"	Recycled PCC	24'
1994	9.0"	Inside Shoulders	4'
1994	9.0"	Outside Shoulders	10'

Design

The existing concrete pavement was designed to be recycled to a thickness of nine inches over a four-inch permeable stabilized base course. The predominant problem with the existing pavement was "D" cracking. The new section includes doweled transverse joints and tied shoulders. See Appendix A for a typical section. Eight experimental sections with various tining widths were incorporated into this project. These are shown in figure 2.

SECTION	STATION	LENGTH (L.F.)
A. skewed 1"	1802+18 to 1782+93 LT	1925
B. 3/4 transverse	1782+93 to 1762+93 LT	2000
C. 2" transverse	1762+93 to 1743+00 LT	2000
D. 3" transverse	1743+00 to 1723+00 LT	2000
E. 4" transverse	1723+00 to 1703+31 LT	1970
Bridge -- no readings	1703+00 to 1701+05 LT	226
F. 1",3",2",4" staggered	1701+05 to 1681+05 LT	2000
G. 1/2 transverse	1681+05 to 1661+05 LT	2000
H. 3/4 longitudinal	1661+05 to 1641+00 LT	1988
I. 1" transverse --- Control	1641+00 to 1621+00 LT	2000

Figure 2

Appendix A contains the state specification on concrete surface texturing and tining.

Construction

The reconstruction on this project began on April 18, 1994. The contractor started placing concrete on July 29, 1994 in the areas selected for the experimental tining sections. Section A was the first section to be completed and began at station 1802+18 left. The paving went from east to west in the north lanes.

Joint bands were placed on the concrete prior to tining. The contractor adjusted the tining spacing for each test section. After tining was completed curing compound was sprayed onto the concrete. A smooth non tined portion was created by the joint bands. This is used as a guide to saw a slight groove with a small chain into the concrete. This groove is used by the concrete saws to cut the joints when the concrete is cured enough.

No special equipment was needed to construct the various tining sections. The tining sections were constructed with minor problems. There were a few grind areas in some of the sections as determined by the DOT's smoothness specification.

Evaluation

Original data was collected from each section in December of 1994. The roadside noise data for 1995 and 1996 was collected in December of each year. The noise data was collected for 1995 at the same stations and locations as they were in 1994. So far there has been no noticeable difference in traffic sound levels from different tining sections. It takes a change in sound levels of more than three decibels to be detected by the average human ear. Based on data collected, the roadside noise readings were discontinued.

Four different vehicles were driven over each of the tining sections. Decibel readings were taken inside the vehicles for each section at 55 and 65 MPH. This was an attempt to determine which tining section produces the most noise. The data at 65 mph is shown on the following pages. This is closer to actual highway speeds. Table 1 contains the base line data for 1994. Table 2 covers the data for 1995 and Table 3 for 1996.

In comparing the data, it shows that the inside vehicle noise had decreased in 1995 but increased slightly again in 1996. The decrease in noise in 1995 was thought to be associated with a small decrease in tining depth. The 1996 data shows the tining depth to have remained the same as 1995 with exception to slightly deeper depths in four sections. These deeper depths most likely are due to the random sampling in each section. The in-vehicle noise readings for 1996 have increased over the 1995 readings. No explanation can be given. All four vehicles were selected to closely match the vehicles used in 1995.

1994 DECIBEL AND TINING READINGS

SECTION NUMBER	AVERAGE DECIBEL READING INSIDE VEHICLE AT 65 MPH				AVERAGE TINING DEPTH	ROADSIDE Db READING L_{10}	
	FORD TEMPO	DODGE SHADOW	CHEVY SUBURBAN	DODGE VAN	RANDOM LOCATIONS	35 FT FROM DRIVING LANE	150 FT FROM DRIVING
A	73.0	74.3	71.3	75.0	1.4 mm	70	65
B	74.3	74.9	71.6	75.2	3.3 mm	71	69
C	73.9	74.2	72.3	73.9	3.1 mm	69	66
D	73.7	73.7	72.2	73.6	2.1 mm	69	68
E	72.8	75.1	71.8	74.3	2.9 mm	70	67
F	73.1	74.2	71.4	74.4	2.9 mm	67	65
G	73.9	74.5	72.7	73.9	2.7 mm	70	69
H	74.7	74.5	72.1	74.7	2.0 mm	69	69
I	75.1	75.8	72.1	76.7	2.9 mm	69	68

Table 1

1995 DECIBEL AND TINING READINGS

SECTION NUMBER	AVERAGE DECIBEL READING INSIDE VEHICLE AT 65 MPH				AVERAGE TINING DEPTH IN INCHES	ROADSIDE Db READING L_{10}	
	FORD TEMPO	DODGE SHADOW	CHEVY SUBURBAN	DODGE VAN	RANDOM LOCATIONS	35 FT FROM DRIVING	150 FT FROM
A	69.9	69.6	68.6	71.7	1/16" (1.6mm)	none taken	none
B	70.5	70.1	68.7	72.5	1/16" (2.1mm)	73	70
C	70.7	70.4	68.8	73.1	1/8" (3.0mm)	74	68
D	70.2	70.2	68.9	72.8	1/16" (1.7mm)	77	70
E	70.9	70.9	69.9	73.4	3/32" (2.4mm)	75	69
F	70.9	70.3	69.6	72.9	1/16" (2.0mm)	none taken	none
G	71.2	70.3	69.3	72.9	1/16" (1.5mm)	73	70
H	71.5	70.5	68.9	72.7	1/16" (1.8mm)	72	69
I	72.5	71.1	68.5	72.8	3/32" (2.5mm)	73	71

Table2

Db = Decibel

1996
DECIBEL AND TINING READINGS

SECTION NUMBER	AVERAGE DECIBEL READING INSIDE VEHICLE AT 65 MPH				AVERAGE TINING DEPTH IN INCHES
	FORD TEMPO 1992	DODGE SHADOW 1994	CHEVY SUBURBAN 1993	DODGE VAN 15 pass 1994	RANDOM LOCATIONS
A	72.4	71.9	68.0	72.8	1/16" (1.8mm)
B	72.3	72.8	68.4	72.9	1/8" (2.9mm)
C	72.2	72.5	69.5	72.8	1/8" (3.6mm)
D	72.2	72.4	68.7	72.8	3/32" 2.6mm)
E	72.5	73.1	69.4	73.8	3/32" (2.4mm)
F	72.5	72.8	69.4	73.7	1/16" (2.2mm)
G	72.3	72.8	69.1	73.4	1/16" (1.6mm)
H	73.4	72.9	69.7	73.4	1/16" (1.6mm)
I	74.4	73.2	71.3	73.7	3/32" (2.5mm)

Table 3

Db = Decibel

A. skewed 19mm(1")
B. 19mm (3/4") transverse
C. 51mm (2") transverse
D. 76mm (3") transverse
E. 102mm (4") transverse
F. 25,76,51,102mm (1,3,2,4 inches)
G. 13mm (1/2") transverse
H. 19mm (3/4") longitudinal
I. standard 25mm (1") transverse (control)

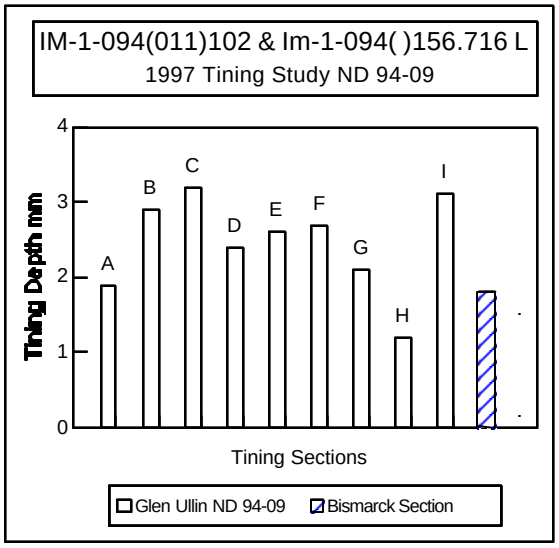
A tire tread depth gauge was used to measure the tining depth. Original tining depth was to be approximately 1/16 inch (2.2mm) deep and not to exceed 3/16 inch (4.8mm) in depth. The specification is found in Appendix A.

All of the tining sections except two were skid tested in 1995. The higher skid number indicates a greater skid resistance with 35 considered to be the minimum desirable skid number. All of the tining sections that were skid tested are well above this minimum. Skid numbers are found in table 4.

SECTION	STATION	SKID NUMBER
A. skewed 1"	1802+18 to 1782+93 LT	58.3
B. 3/4 transverse	1782+93 to 1762+93 LT	56.6
C. 2" transverse	1762+93 to 1743+00 LT	------
D. 3" transverse	1743+00 to 1723+00 LT	56.5
E. 4" transverse	1723+00 to 1703+31 LT	54.1
Bridge -- no readings	1703+00 to 1701+05 LT	------
F. 1",3",2",4" staggered	1701+05 to 1681+05 LT	52.3
G. 1/2 transverse	1681+05 to 1661+05 LT	57.0
H. 3/4 longitudinal	1661+05 to 1641+00 LT	------
I. 1" transverse --- Control	1641+00 to 1621+00 LT	56.1

Table 4

No skid testing was performed on the tining sections in 1996 or 1997. No study of the surface moisture runoff was undertaken. The 1997 tining depths at the Glen Ullin tining sections and the random tining project at Bismarck, are shown in the following chart.



The Minnesota and Wisconsin Departments of Transportation have conducted a study regarding the use of randomly spaced tining to reduce road noise. The study shows there is less noise with the randomly spaced tining. Based on this study and other studies conducted by the North Dakota Department of Transportation, randomly spaced tining was constructed on the west-bound lanes of I-94 at Bismarck. The project number is IM-1-094(017)156. The traffic for this area is shown in table 5.

Year	Cars	Trucks	Total ADT	Rigid Pvmn't ESAL's	Remarks
1997	8550	740	9290	900	Grant Marsh Bridge to Ward Road westbound lanes
1997	6750	780	7530	980	Ward Road to US 83 --westbound lanes
1997	4320	640	4960	810	US 83 to East Bismarck Interchange---westbound lanes

Table 5

The spacing was developed using a random number generator. This project was evaluated and is included in this report. The tine spacing used is shown in table 6.

1¼	1¼	⅞	1	1¼	¾	⅞	¾	¾	1¼
¾	1⅛	1¼	¾	⅞	⅝	¾	⅜	⅝	1⅛
⅝	⅜	1¼	1¼	1½	1¼	⅞	1½	1½	1
¾	⅞	¾	1⅛	½	⅝	¾	¾	1½	1⅛
⅞	⅜	1¼	1¼	⅝	⅝	1	⅝	1	⅜
1½	1¼	⅝	1⅛	1¼	¾	⅝	1	¾	¾
⅞	¾	¾	¾	¾	⅝	⅞	1¼	1⅛	⅞
1¼	1¼	1	⅞	¾	½	1¼	1¼	½	¾
⅞	¾	1¼	¾	¾	⅞	¾	1⅛	1¼	¾
¾	¾	½	1¼	¾	1¼	⅞	½	1¼	⅝
⅝	1½	⅜	1⅛	1¼	⅝	1¼	½	½	½
⅝	1	¾	1⅛	⅞	¾	¾	1⅛	1⅛	½
⅞	⅞	1¼	1½	1½	¾	½	½	1¼	⅝
⅝	1⅛	⅜							

Note: This spacing was developed using a random number generator. The spacing is ⅜" # x# 1½", with at least 50% <1". The spacing represented above has a total length of 10 feet.

Table 6

Tining depth was measured at two locations on the project. These locations were at station 375+00 and 470+00. The average tining depth was 1.8mm or 1/16". As in the Glen Ullin tining sections, four vehicles were driven over the project. Noise was measured inside each vehicle using a decibel reader. Table 7 contains the data averages.

Using noise data from 1994,1995, and 1996,it shows that decibels will increase from 4 to 5½% as the vehicle speed increases from 55 to 65 MPH. This is determined using data from tables 1,2, and 3. The noise readings from table 7 show that in this randomly spaced tining project, the decibels increased 3.8% when increasing vehicle speed from 55 to 65 MPH.

This seems to indicate that the randomly spaced tining at Bismarck is producing lower decibel readings than the other sections at Glen Ullin. The tining depth seems to be less in the randomly spaced tining section at Bismarck. This may affect the noise measurements to a greater degree than the tine depth. Tine spacing is related to the whine produced by the tires of a vehicle.

I-94 mile 160 to 158 Westbound
In Vehicle Noise and Tining Depth Readings

Vehicle	Average decibel inside vehicle		Tining Depth -- mm
	55 MPH	65 MPH	
1997 Chevy Suburban	68.5	71.9	1.8
1990 Chevy Cavalier	70.3	73.4	
1994 Dodge 12 Passenger Van	72.2	73.8	
1996 Dodge Neon	71.2	74.1	

Table 7

Photo 2. View of random tine spacing

Summary

Exterior noise measurements for tined PCC pavements exhibit certain frequencies. Some tining sections will produce an objectionable pavement whine. This pavement whine is usually associated with tining spacings that are 2" or greater. Pavement tire noise increases with speed. The noise study indicates that as the vehicle speed increases from 55mph to 65mph, a 4 to 5½% increase in decibel reading can be expected.

No decibel readings were taken in grind areas. The in-vehicle noise study indicates that sections with close tine spacing are usually the quietest. The higher readings are found in sections with 2" or greater tine spacing. The control section with 1" standard tine spacing was also rather noisy. The control section is located up hill and vehicle acceleration may be influencing the readings. There is not a great difference in the decibel readings between sections. A difference of ± 3db in noise level is needed to be detected by the human ear.

All the test sections fell within this range. Overall, it appears there is no noticeable difference in traffic sound levels from different tining spacings.

The North Dakota Department of Transportation decided to use randomly spaced tining on the west-bound section of I-94 at Bismarck. The project number is IM-1-094(017)156. The randomly spaced tining is producing slightly lower in-vehicle decibel readings than in the experimental sections at Glen Ullin.

Based on studies conducted by the DOT and others, the NDDOT has adopted the random tine spacing and is included in the states standard specifications. The new specification can be seen in Appendix A. This adopted action has prompted the closing of this experimental study. The objective of the study has been acheived

Recommendations

Never use a tining spacing greater than 1½ inch. Continue using the random tine spacing method recently adopted.

Appendix A

DESIGN DATA				
Traffic	Average Daily			Est.Max.Hr
Current 1993	Pass. 3500	Trucks 750	Total 4250	420
Forecast 2013	Pass. 5250	Trucks 1050	Total 6300	630
Minimum Sight Dist. for:		Design Speed 70 MPH		
Stopping 600'				
Full Control of Access				
No Point of Access Other Than at Interchange Ramps				

JOB# 13

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	IM-1-094(011)102	1

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

FEDERAL AID PROJECT IM-1-094(011)102
IN
MORTON COUNTY
RECYCLED PCC PAVEMENT AND INCIDENTALS
(NORTH ROADWAY)

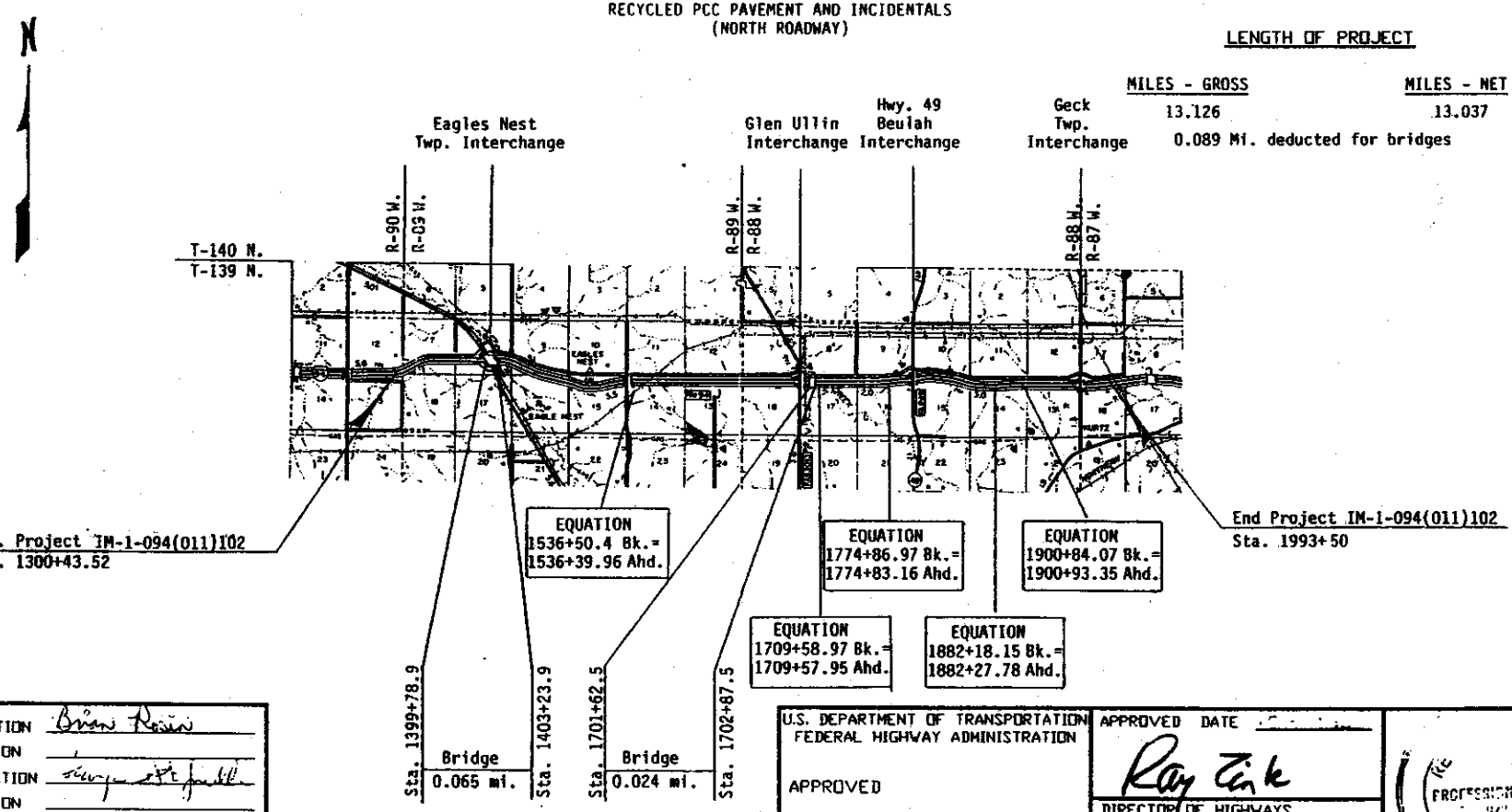
GOVERNING SPECIFICATIONS:

Standard Specifications adopted by the North Dakota Department of Transportation September 1992; Standard Drawings currently in effect; and other Contract Provisions submitted herein.

LENGTH OF PROJECT

MILES - GROSS	MILES - NET
13.126	13.037

0.089 Mi. deducted for bridges



PAVING SECTION Brian Rosin
URBAN SECTION
TRAFFIC SECTION
RURAL SECTION
RECOMMEND APPROVAL 10-1, 1993
DESIGN ENGINEER David K. Fox

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ADMINISTRATOR DATE

APPROVED DATE

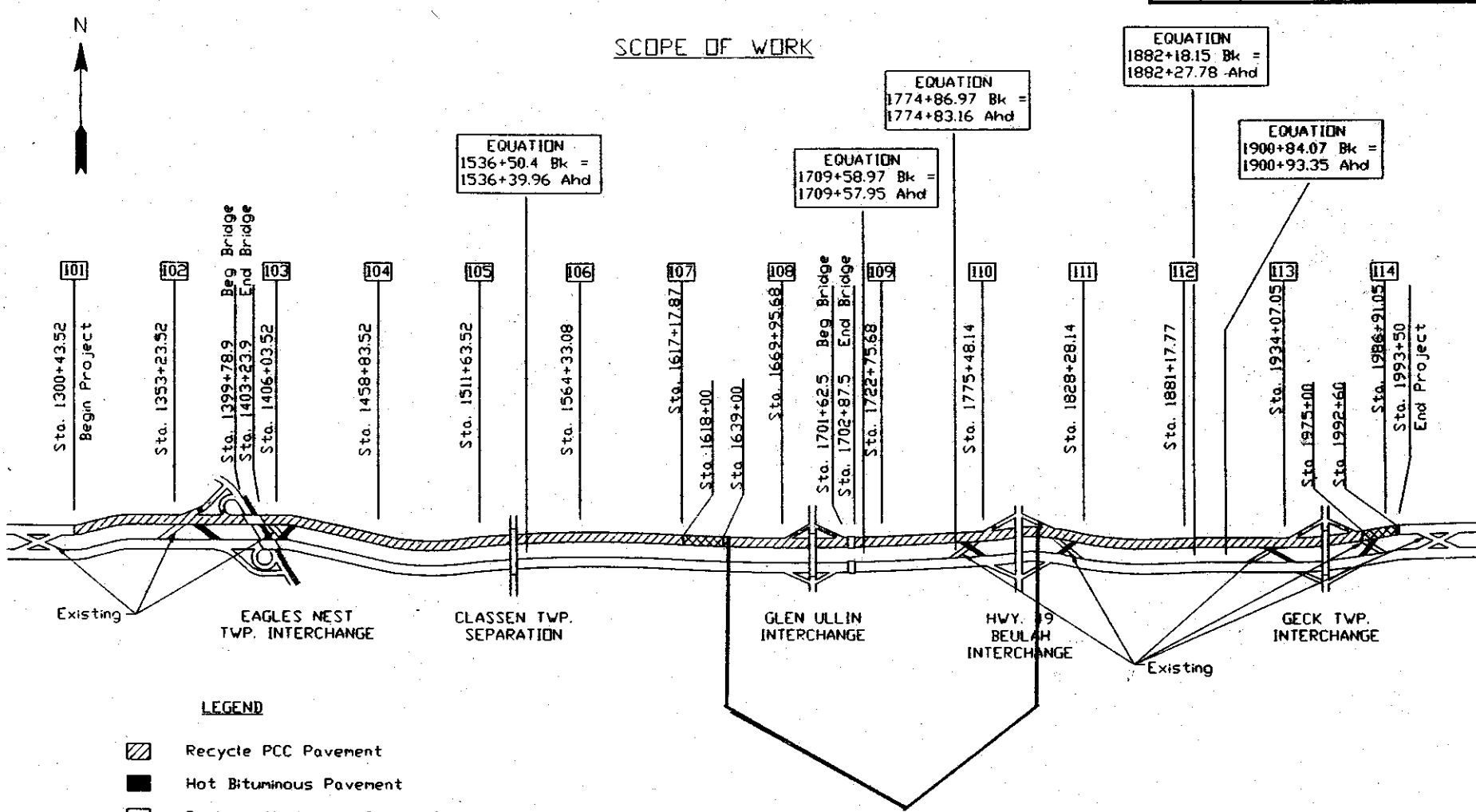
Ray Zink

DIRECTOR OF HIGHWAYS AND ENGINEERING
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

PROFESSIONAL ENGINEER NORTH DAKOTA

A-1

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-1-094(011)102	3



Experimental tining sections

A-2

TYPICAL SECTION

North Roadway
Mainline

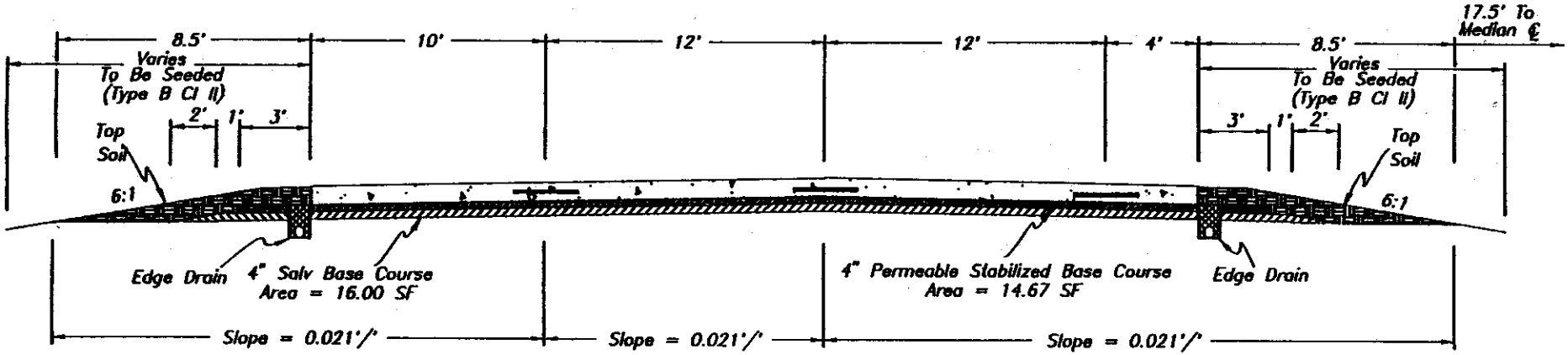


Figure 2

550.04 CONSTRUCTION REQUIREMENTS.

J. Finishing Concrete.

6. **Final Surface Finish.** After surface irregularities have been removed and before the concrete attains an initial set, a seamless strip of stiff-fiber artificial grass carpet shall be dragged longitudinally along the full width of the pavement. The surface texture shall be uniformly roughened leaving corrugations in the surface that are uniform in appearance, approximately 1/16 inch deep and not exceeding 3/16 inch in depth. The width of material in the drag shall be in contact with the full width of the pavement. The drag shall be operated with its leading edge attached to a bridge riding on the forms or adjacent slabs. The drag shall be maintained clean and free from encrusted mortar. A drag that can not be cleaned shall be replaced with new fabric.

   Immediately following the grass carpet drag, the surface shall be given a transverse metal tine finish. The tining device shall consist of a single row of tines capable of producing grooves at approximately one-inch centers with groove widths of 1/8 inch and groove depths of 1/8 to 3/16 inch. There shall be no tine finish within 1 1/2 inches of the transverse contraction joints. The texturing equipment shall be self-propelled and mechanically operated.

7. **Imprinting Pavement.** After texturing, the survey station numbers shall be imprinted into the surface by the Contractor about one foot from the edge of the pavement so the numbers can be read in the direction of traffic driving on the outside shoulder. On 2-way roadways, the station numbers shall be imprinted in the direction of stationing. In addition at the beginning and end of each day's pour, the station number to the nearest foot shall be placed at the right edge of slab.

   The month, day, and year shall be imprinted at the beginning and end of each day's pour near the edge of the slab opposite that used for stationing so the numbers can be read in the direction of the pour.

   The Contractor shall furnish devices for imprinting the pavement. The numerals shall be 3 to 4 inches in height and at least 1/4 inch in depth.

K. Curing Concrete.

The screeds shall be adjusted so a small quantity of concrete or mortar is carried ahead of each screed. Screeds shall be operated to avoid displacing or damaging joint installations. Segregated concrete or mortar carried ahead of the screeds shall not be deposited on or adjacent to any joint. If concrete is placed at a rate of less than 250 feet per hour one screeding machine may be used provided results are satisfactory and the screeding machine is operated at least twice over each area of pavement.

4. **Floating.** Long-handled floats, having blades at least 5 feet in length and 6 inches in width, may be used to smooth and fill in open-textured areas of pavement.

5. **Straightedging.** While the concrete is still plastic, the Contractor shall test the slab surface for trueness with a 10-foot straightedge meeting Section 153.10 B. The straightedge shall be placed parallel to the pavement centerline and shall be passed over the slab to reveal any high areas or depressions. High areas shall be struck off and low areas shall be filled with fresh concrete. The areas corrected shall be consolidated and refinished with a long-handled float. Hand floats shall be operated across the pavement by starting at the edge and slowly moving to the center and back again to the edge. The float shall then be moved forward and the operation repeated. Only enough floating shall be done to seal the surface and care shall be taken to preserve the required cross section of the pavement. The surface shall be checked again with a 10-foot straightedge and any irregularities eliminated. Surplus water or laitance on the pavement surface shall be wasted outside the forms. Successive advances of the straightedge along the pavement shall lap the previously straightedged area by not less than 1/2 the length of the straightedge. Special attention shall be given to assure the surface across joints meets requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is free from observable depression below the straightedge, and the slab conforms to the required grade and cross section.

6. **Final Surface Finish.** After surface irregularities have been removed and before the concrete attains an initial set, a seamless strip of stiff-fiber artificial grass carpet shall be dragged longitudinally along the full width of the pavement. The surface texture shall be uniformly roughened leaving corrugations in the surface that are uniform in appearance, approximately 1/16 inch deep and not exceeding 3/16 inch in depth. The width of material in the drag shall be in contact with the full width of the pavement. The drag shall be operated with its leading edge attached to a bridge riding on the forms or adjacent slabs. The drag shall be maintained clean and free from encrusted mortar. A drag that can not be cleaned shall be replaced with new fabric.

   Immediately following the grass carpet drag, the surface shall be given a transverse metal tine finish. The tining device shall consist of a single row of tines capable of producing grooves at groove widths of 1/8 inch and groove depths of 1/8 to 3/16 inch. The tines shall be randomly spaced at widths of 3/8 inch to 1 1/2 inches. At least 50% of the spaces between the tines shall be less than 1 inch in width. There shall be no tine finish within 1 1/2 inches of the transverse contraction joints. The texturing equipment shall be self-propelled and mechanically operated.

ND Revised Tining Specification, April 19, 1997