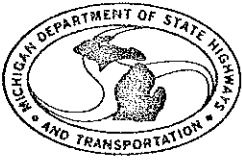


PERFORMANCE EVALUATION OF TRINIDAD
ASPHALT CEMENT FOR BITUMINOUS
CONCRETE RESURFACINGS



MICHIGAN DEPARTMENT OF STATE HIGHWAYS



OFFICE MEMORANDUM

May 23, 1975

TO: F. Copple, Supervisor
Pavement Performance Group

FROM: C. A. Zapata

SUBJECT: Transverse Cracking Reflected Through Asphaltic Concrete Resurfacing. Research Project 73 C-16. Research Report No. R-962.

In response to your request, a detailed cracking survey of the Trinidad resurfacing project was conducted on April 9, 1975. After eight months of service under traffic, none of the test sections showed any significant load-associated distress, such as distortion, deformation or rutting. The only type of pavement distress visible was transverse cracking reflected through the asphaltic concrete resurfacing. About 95 percent of these cracks extended full lane width. The initial results, after the first winter, are summarized in the attached table. The data indicates the following:

1. Two-course asphaltic resurfacing retarded reflection cracking better than one-course overlay.
2. One-course resurfacing with conventional 85-100 penetration grade asphalt showed better resistance to reflection cracking than one-course resurfacing with Trinidad.
3. Section 7 of the two-course conventional asphalt overlay showed almost 13 percent of the original cracks reflecting through. All other sections of two-course overlay, both conventional and Trinidad showed less than 1 percent reflection cracking.

Since the relative performance of the test sections is still inconclusive, we should continue field observations for at least two more winters.

TESTING AND RESEARCH DIVISION

Carlos A. Zapata

C. A. Zapata - Physical Research
Engineer - Physical Research Unit

CAZ:bf

SUMMARY OF TRANSVERSE CRACKS REFLECTED
DURING THE FIRST WINTER

Research Project 73 C-16, April 1975 Survey
(US 27 North of Snowbowl Rd to M 55, Age of Resurfacing: 9 months)

Material	Section Number	Number of Visible Transverse Cracks		
		Original	Reflected	Percentage Reflected
Trinidad 6.5 percent	10*	492	68	13.8
	15*	761	28	3.7
	2	1,045	7	**
	9	552	5	1.0
	14	906	4	**
	5	498	0	0
Trinidad 6.0 percent	11*	495	152	30.7
	16*	518	125	24.1
	8	641	3	**
	13	775	1	**
	4	581	1	**
	1	636	0	0
Conventional 6.0 percent	7	633	80	12.6
	6*	1,087	63	5.8
	3*	1,009	58	5.7
	12	1,224	12	1.0
	3	1,876	7	**
	6	1,581	1	**

* Resurfacing consisted of wearing course only. All other sections consisted of both leveling and wearing courses. Sections 3 and 6 consisted of both single-course (40 percent of the length) and two-course (60 percent of the length) resurfacing.

** Less than 1 percent.

PERFORMANCE EVALUATION OF TRINIDAD
ASPHALT CEMENT FOR BITUMINOUS
CONCRETE RESURFACINGS

C. A. Zapata

Research Laboratory Section
Testing and Research Division
Research Project 73 C-16
Research Report No. R-962

Michigan State Highway Commission
E. V. Erickson, Chairman; Charles H. Hewitt,
Vice-Chairman, Carl V. Pellonpaa, Peter B. Fletcher
John P. Woodford, Director
Lansing, April 1975

ACKNOWLEDGEMENTS

The author wishes to thank the following persons for their cooperation in this experimental project, R. E. Oja, Project Engineer; Morley Durston of the Lake Construction Co.; L. J. McAllister of the Great Lakes Asphalt Co.; C. D. Church of the Testing and Research Division; Merlin Tiedt, Leo Batemen, Robert Kownover, Robert Downing, Leo DeFrain, Lio Bateman, Philip Luce, Kenneth Kassner, and Paul Schafer of the Highway Research Laboratory Section and Lawrence Parr, highway photographer.

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ABSTRACT

Trinidad asphalt cement manufacturers claim that an anti-skid, smooth riding, durable, and economical resurfacing can be obtained by using a fluxed or blended Trinidad asphalt as the bituminous material for asphalt concrete pavement (4.12 of the MDSHT Standard Specifications). The purpose of this study is to test the validity of this claim by comparing the performance of blended Trinidad resurfacing with a conventional overlay using regular refined 85-100 penetration grade asphalt. Field observations before, during, and after the resurfacing work were made at the experimental site which consisted of 4.9 miles of four-lane divided highway. These included; extent and severity of cracking of the old surface, mix design, plant production and paving operations, construction problems and construction costs, density, skid resistance, and riding quality tests. Based on preliminary results, it is concluded that:

1) Trinidad resurfacing was applied over pavement with cracking conditions of relatively greater severity than that covered with conventional asphalt. If the Trinidad resurfacing reduces or eliminates reflection cracking under these conditions, it should do well in nearly any application.

2) Acceptable tolerances within the standard specifications were observed during the resurfacing work including mix design, plant production, and paving operations. Also, regular inspection, control practices, and workmanship were satisfactory throughout the experimental project.

3) A nine-hour trip from the Trinidad source to the plant site caused a segregation problem in each shipment. Settled particulate material required compressed air to break it up, and keep fine particles in suspension.

4) In general, none of the asphalt mixtures presented difficulties in spreading, compacting, and finishing with conventional equipment. In cool weather, however, with temperatures in the low 60's, Trinidad mixtures being placed at temperatures below 300 F developed some compaction problems such as ripples or waves over the layer being compacted. In this case vibratory rolling was required (in a short Trinidad section) to achieve proper compaction.

5) Construction costs for Trinidad asphalt sections were up to 76 percent higher than those for conventional sections.

6) Initial performance characteristics between Trinidad and conventional resurfacings showed very small differences in surface texture, color, compaction or densification, skid resistance, and riding quality. For all practical purposes, all the test areas were about equal in performance characteristics. Thus, at this point, the chief difference between the two asphaltic materials was the initial construction cost.

If the Department contemplates further resurfacing jobs with Trinidad asphalt; three major points should be considered:

1) Better blending arrangements in trucks transporting fluxed Trinidad asphalt to the plant site are needed. The existing air agitating system in the shipping drum was inoperative while the truck was in motion. Such faulty agitating design caused about 30 minutes delay in plant operations for each shipment of materials.

2) In cold days, placing and compacting Trinidad mixtures at rolling temperatures below 300 F should not be attempted with conventional equipment. Vibratory compaction is required under such conditions. Conventional equipment operates properly for rolling temperatures above 300 F.

3) Since Trinidad producers claim that, as pavement ages, Trinidad asphalt should give more quality performance per dollar invested than conventional asphalts, seasonal surveys of the test areas should be continued for at least five years. Further, after five years service it is hoped to estimate surface durability in resisting cracking, deformation, and other pavement failures.

INTRODUCTION

The Problem

Economical construction and maintenance of durable, stable, anti-skid, bituminous surfacings is a constant problem for roadbuilders. The Department, like other highway agencies, is continually concerned with the evaluation of new materials that may upgrade the performance of heavily traveled highways.

A common method of improving old pavements is to first correct surface irregularities with a bituminous leveling mixture and then to resurface with a bituminous concrete wearing course. Where surface irregularities are practically nonexistent, the old pavement is rehabilitated with the wearing course mixture only. Trinidad producers have suggested that economical, durable, stable, and non-skid resurfacings can be obtained by using a fluxed Trinidad asphalt as the bituminous material for Bituminous Concrete Pavement, 4.12 of the MDSHT Standard Specifications. A performance evaluation of this asphalt material is the main purpose of this investigation.

Objectives

Specifically, this comparative study is designed to:

1) Compare the qualities and properties of the asphalt concrete mixes and their service performance under traffic and weather conditions. Specifically, performance will be evaluated by compiling and analyzing field data in terms of surface compaction, skid resistance, riding quality, and surface durability in resisting long-term cracking, deformation, and other pavement failures.

2) Compile and compare construction costs. Discuss construction problems, if any, that may occur under normal job control and write interim and subsequent reports as needed.

Background

Trinidad Lake Asphalt (referred to here as "Trinidad") was found on the Island of Trinidad in 1595. The island lies about 50 miles off the northeast coast of South America and about 2,000 miles south of New York. Trinidad is dug from a lake, melted, refined, and drummed for shipment to several countries. It was imported into the United States during the 1915-1939 period and sold for resurfacing jobs in many cities such as Buffalo,

New York; Baltimore, Maryland; Chicago, Illinois; Kansas City, Kansas; Harrisburg, Pennsylvania; Reading, Pennsylvania; and Detroit, Michigan. To date, 79 Trinidad roads have been built in the State of Indiana. Promotional literature for Trinidad claims that although first costs are higher for Trinidad than for conventional asphalt roads, these additional costs will be amply repaid in later years in terms of four important road properties; greater skid resistance, improved surface riding qualities, less road glare, and longer service. In May 1973, to test the validity of these claims, the Department took preliminary steps to draft a supplemental specification for the Trinidad asphalt and select a test area for a comparative study with conventional asphalt. At the same time, L. J. McAllister of Great Lakes Asphalt, Inc. (a supplier of Trinidad asphalt) suggested a provisional specification similar to that of the State of Indiana.

As a result of such preliminary discussions, the Department approved a supplemental specification (Appendix) for the Trinidad asphalt to be used in the proposed study. The selected test area consisted of 4.9 miles of four-lane divided highway on US 27 in Roscommon County from Snowbowl Rd northerly to the M 55 crossover. The 13-year old experimental area, carrying an average daily traffic of 9,200 vehicles in 1972, was originally built as a three-course asphaltic concrete pavement. Before resurfacing, it was badly scaled and cracked. Initially, the test area was to be resurfaced with asphaltic concrete mixtures applied at the rate of 250 lb/sq yd, but because of budget constraints, this application rate was later changed to 180 lb/sq yd. In October 1973, at the request of K. A. Allemeier, Testing and Research Engineer, the Research Laboratory Section designated the test area as a resurfacing project to compare the performance characteristics of Trinidad asphalt with conventional bitumen. By incorporating an asphalt material unique to present construction methods and practices, construction done for this research study is defined by the FHWA as Experimental Highway Construction, Category 2. For this resurfacing work, in a letter to C. D. Church (November 16, 1973) P. J. Serafin, Bituminous Engineer, recommended 6.0 or 6.5 percent "fluxed" Trinidad¹.

Subsequently, during a preconstruction meeting held on December 20, 1973, copies of a work program for the experimental project were reviewed, modified, and approved by the Project Engineer, the contractor, and research personnel involved in the study. On June 13, 1974, Lake Construction Co., low bidder for the work, began resurfacing the test area.

¹ In this study the term "fluxed" means that the refined Trinidad (called 'Epure') should be blended with 70 to 75 percent conventional 85-100 penetration asphalt.

PRELIMINARY CONSIDERATIONS

Design characteristics of the experimental project (Mb 72013) selected for this study are shown in Figure 1. The experimental layout is shown in Figure 2.

Trinidad asphalt cement was used in bituminous concrete 4.12 from Station 450+00 to 612+00 on the northbound roadway, conventional 4.12 bituminous concrete was used over the same length of the southbound roadway. From Station 612+00 to 706+00 Trinidad bituminous concrete was used on the southbound roadway and conventional bituminous concrete on the northbound. These sections will be compared with conventional 85-100 penetration asphalt cement to be used in the remaining sections of this project.

Although, time, manpower and monetary limitations did not permit the use of replicated, balanced, randomized test sections, the project layout should perform satisfactorily for a comparative study. Subsequent observations and periodic condition surveys should give a general evaluation as to whether one type of material will perform better than the other. The requirements of the blended Trinidad asphalt cement proposed for this project are shown in the Appendix. Also included is an analysis (from the Chicago Testing Laboratory) of Trinidad samples taken from the first shipment tank sent to the plant site.

Crack Surveys

Since the overall performance of a resurfacing treatment is greatly affected by the condition of the existing road surface, condition surveys of the test area were conducted before any bituminous mix was applied. These surveys compiled detailed measurements of single and multiple longitudinal cracks, transverse cracks, and alligator or map cracking. Figure 3 shows typical surface distress conditions before being resurfaced. Results of the crack surveys are summarized in Table 1 and Figures 4 and 5. The extent of cracking, as expected, was greater on the traffic lane than on the passing lane of both roadways.

Since all 16 test sections will be compared, note that resurface treatment with blended Trinidad must cover surface cracking ranging from 8 to 140 lin ft of single and multiple longitudinal cracks (per 100-ft station); from 4 to 28 transverse cracks per 100-ft station; and from one to 14 percent of the area of each test section suffering from map cracking. The conventional resurfacing must cover pavement cracking ranging from 1 to 111 lin ft per 100-ft station for single and multiple longitudinal cracks; from 4 to 33 trans-

verse cracks per 100-ft station; and from 1 to 7 percent of map cracking area per test section. Briefly, Trinidad resurfacing must cover cracking conditions of relatively greater severity than that to be covered by conventional asphalt.

TABLE 1
SUMMARY OF CRACK CONDITIONS OF THE ORIGINAL 13
YEAR OLD ASPHALTIC CONCRETE PAVEMENT

Construction Project Mb 72013
February 1974 Survey

Northbound Roadway	Traffic Lane	Passing Lane
Longitudinal cracks, (single plus multiple), lin ft per 100-ft sta	73.6	29.1
Transverse cracks, number per 100-ft sta	16.3	11.0
Alligator or map cracking, percent of road surface	5.0+	1.0+
Southbound Roadway	Traffic Lane	Passing Lane
Longitudinal cracks, (single plus multiple), lin ft per 100-ft sta	68.6	36.3
Transverse cracks, number per 100-ft sta	17.9	14.6
Alligator or map cracking, percent of road surface	4.0+	3.0+

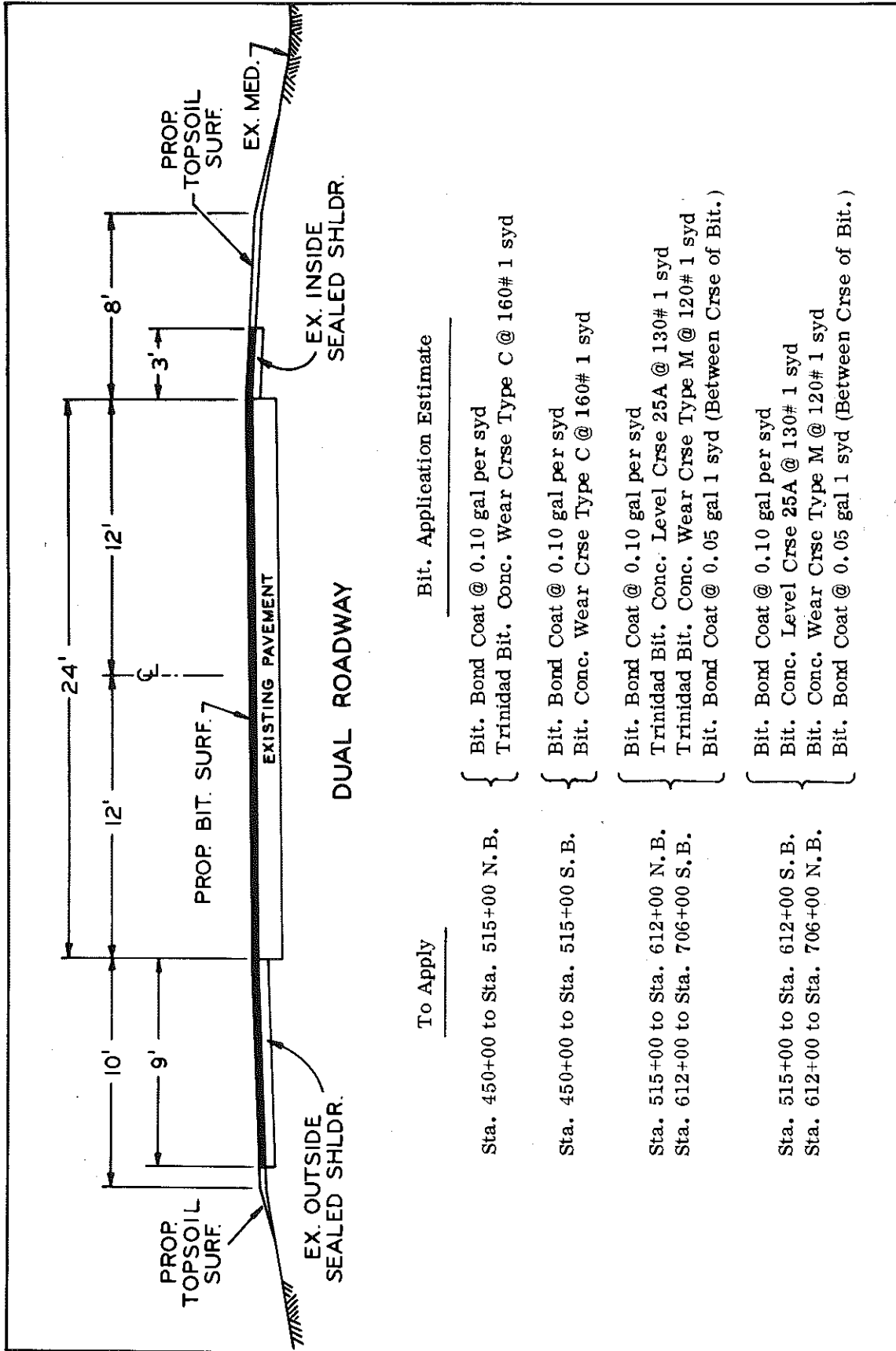


Figure 1. Typical cross-section of Construction Project Mb 72013.

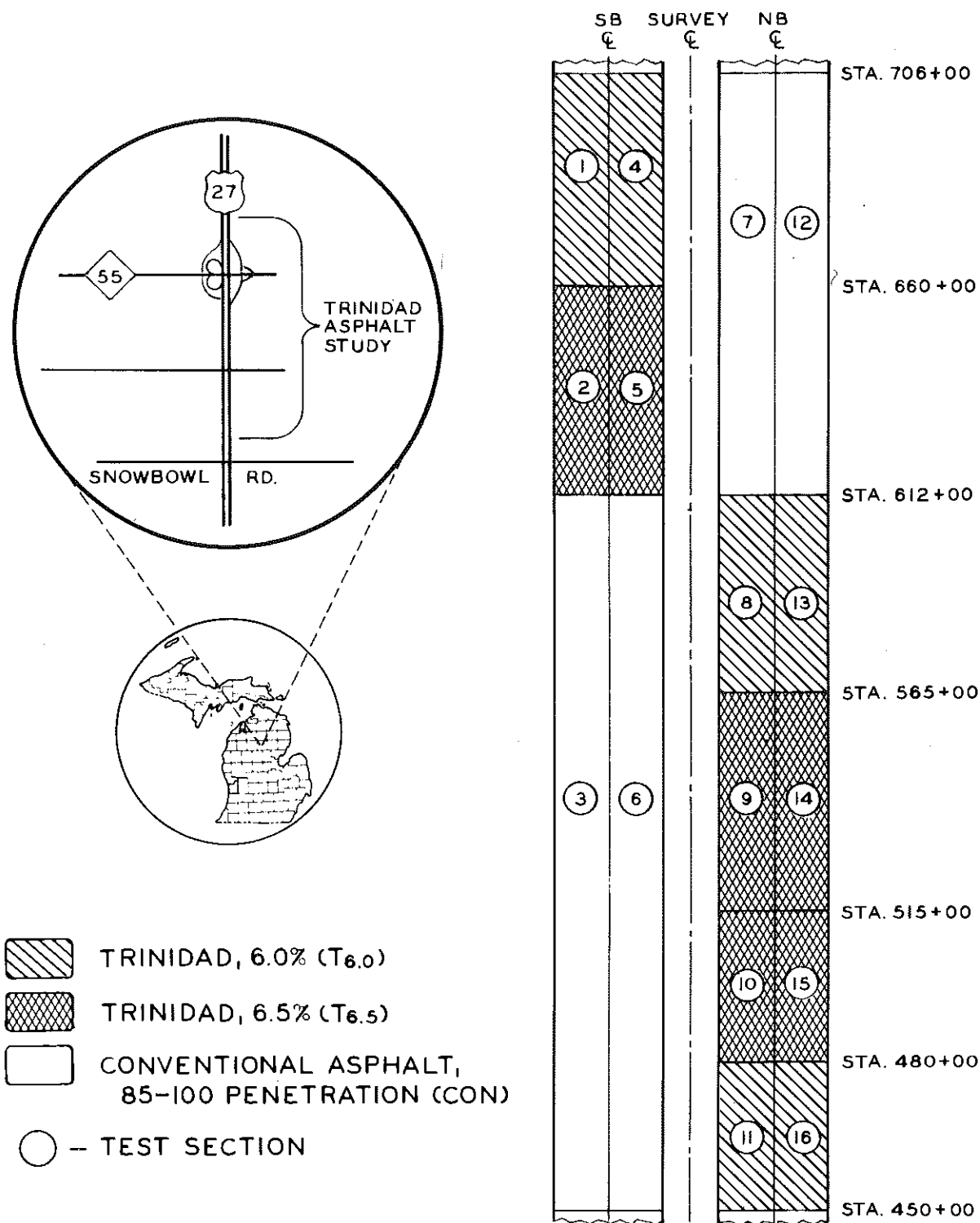
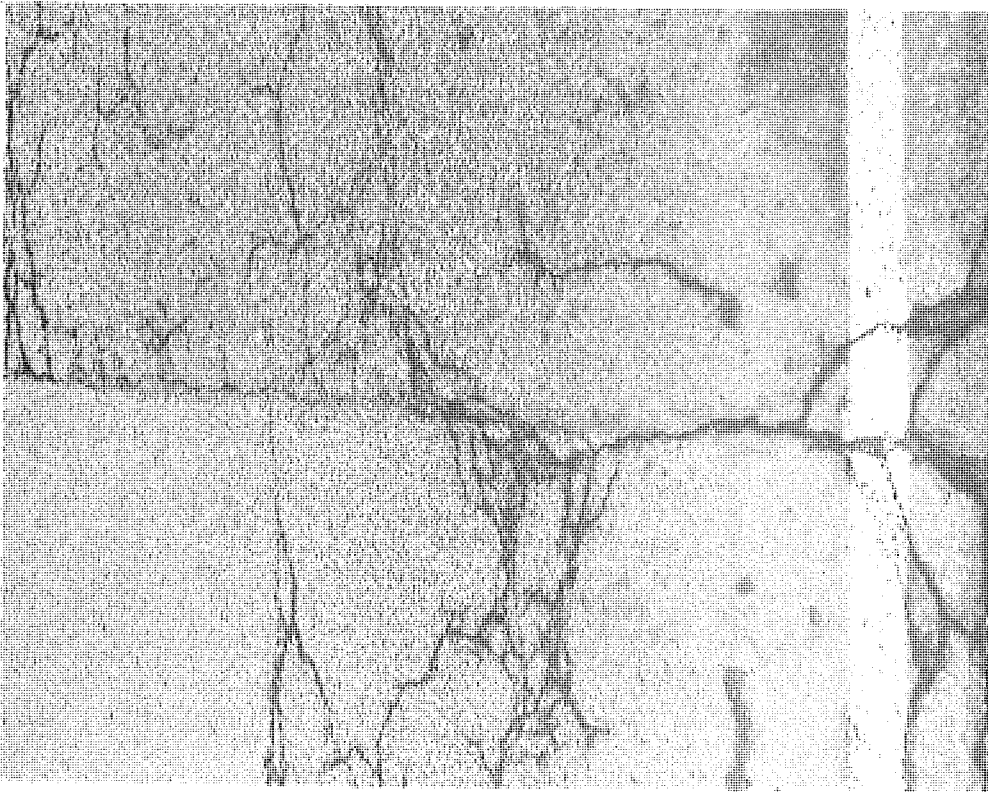


Figure 2. Experimental layout comparing Trinidad and conventional asphalt resurfacing over 4.9 miles of four-lane divided highway. The test area is divided into a total of 16 test sections.

Sta. 695+00 northbound roadway. Typical combination of transverse and alligator or map cracking. Cracks were opened about 1/4 in. when photographed (December 1973).



Sta. 540+00 southbound roadway. Typical crack pattern developed on traffic lane of test section 3. Photographed December 1973.

Figure 3. Typical distress conditions of the original 13-year old asphaltic concrete pavement, Construction Project Mb 72013/06140A, US 27 west of Houghton Lake.

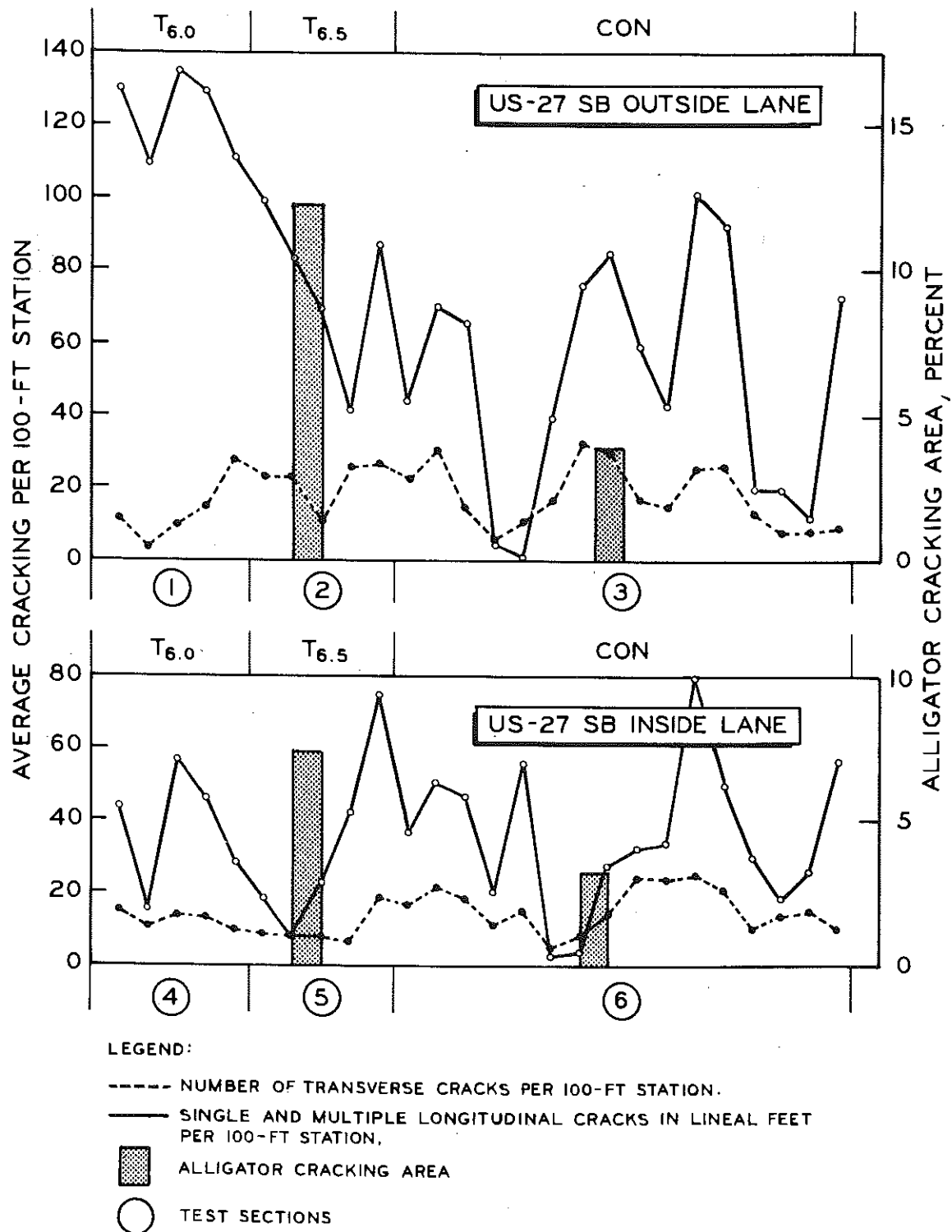


Figure 4. Summary of February 1974 cracking survey, southbound roadway US 27, Construction Project Mb 72013/06140A.

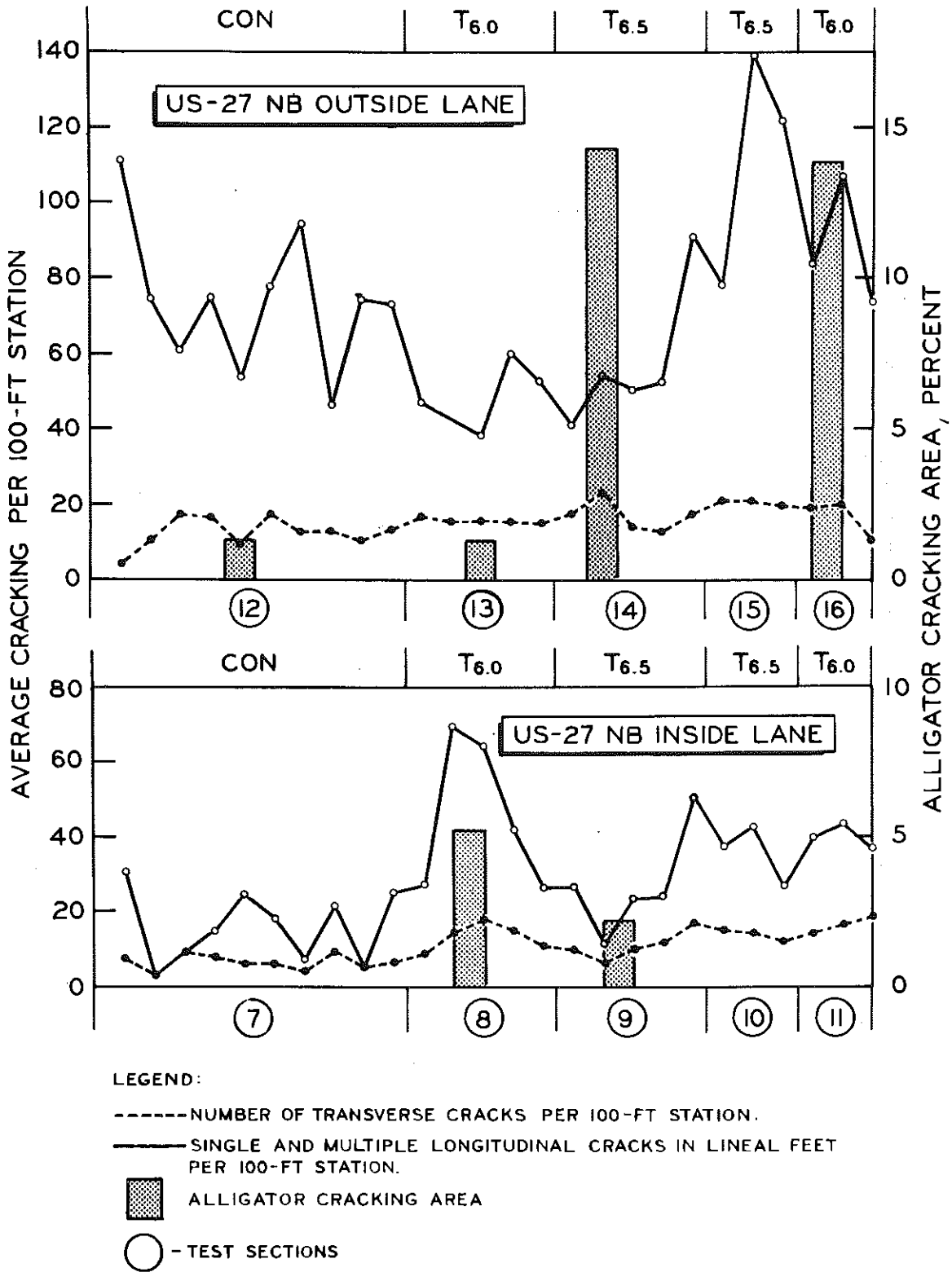


Figure 5. Summary of February 1974 cracking survey, northbound roadway US 27, Construction Project Mb 72013/06140A.

Leveling Course

To produce the specified gradation for the bituminous concrete leveling mixture 4.12 of the MDSHT Standard Specifications (Appendix), it was required that 25A coarse aggregate, 3CS sand, and asphalt be properly combined and mixed at the asphalt plant. Trinidad mixtures were proportioned by weight in 6,000-lb batches containing 58 percent coarse aggregate, 36 percent sand, and 6 percent fluxed asphalt. Mixing times for the materials in the pugmill were 8 seconds of dry mixing and 25 seconds of wet mixing. Mixing temperatures were maintained between 330 and 350 F. Initially, the experimental study called for two different percentages (6.0 and 6.5) of Trinidad asphalt, but after experimenting with Trinidad mixes, preliminary results showed no observable differences in quality characteristics between both types of Trinidad mixes. Therefore, the leveling course was set at 6.0 percent Trinidad asphalt. This fixed asphalt content was also justified on two other accounts; uniformity of construction and cost savings. Conventional bituminous materials contained 59 percent coarse aggregate, 36 percent sand, and 5 percent conventional 85-100 penetration grade asphalt. Mixing times included 5 seconds for dry mixing and 25 seconds for wet mixing. Daily bituminous plant reports showed that gradation results and asphalt content both complied with specifications.

Wearing Course

To produce the specified gradation for the bituminous concrete wearing mixture 4.12 of the MDSHT Standard Specifications (Appendix), four different types of mixes were required according to the experimental design (Fig. 1).

Trinidad mixture materials were proportioned by weight in 6,000-lb batches for two types of wearing courses:

- 1) 25A Type C mix containing 40 percent coarse aggregate, 50 percent sand, 4 percent filler, and 6 percent Trinidad for test sections 11 and 16; and 6.5 percent Trinidad for test sections 10 and 15. Mixing times included 10 seconds for dry mixing and 25 seconds for wet mixing.

- 2) 31A Type M mix containing 30 percent coarse aggregate, 59 percent sand, 5 percent filler and, 6 percent Trinidad for test sections 1, 4, 8, and 13; and 6.5 percent Trinidad asphalt for test sections 2, 5, 9, and 14. Mixing times included 15 seconds for dry and 30 seconds for wet mixing.

For conventional bituminous mixes, the bitumen content was set at 6.0 percent for both types of wearing courses. Materials proportions and mixing times were about the same as those for fluxed Trinidad mixes.

Daily reports from the bituminous plant showed that gradation results and asphalt content both complied with specifications.

CONSTRUCTION

An agreement was reached with construction personnel that the proposed evaluation study be conducted without interfering with normal, routine inspection and construction procedures and that the regular practice, when necessary, be modified only to insure the uniformity required by the experimental study.

Construction of the test area began on June 13, 1974 and was completed August 2, 1974. The resurfacing work was conducted with conventional equipment, construction procedures, and controls as specified in current MDSHT Standard Specifications, Section 4.12 "Bituminous Concrete Pavement," and the Construction Manual (p 456). About 3/4 of the test area consisted of two-course construction: a leveling course using 25A coarse aggregate applied at a rate of 130 lb/sq yd and a Type M wearing course using 31A coarse aggregate applied at a rate of 120 lb/sq yd. A bituminous bond coat was applied over the old surface (0.10 gal/sq yd) and between courses (0.05 gal/sq yd). The remaining 1/4 of the test area consisted of a bond coat and a 25A Type C wearing course applied at a rate of 160 lb/sq yd. An automatic batch plant with rated capacity of 300 ton/hour and located about 15 miles northeast of the project was used to produce up to 19 tons per station of asphaltic mixtures. The hot mix was conveyed and stored in a 100-ton capacity surge bin to maintain a continuous supply of bituminous mixture. The hot mixtures were discharged into insulated 30 to 50 ton trucks and delivered to the paver at temperatures mostly over 300 F. A Barber-Greene paver moving at a speed of 30 ft/minute paved the passing lane, with one pass; a width of 15-ft (12-ft lane and 3-ft of inside shoulder). Once this lane was compacted and finished, another paver resurfaced the traffic lane with one pass; a width of 21-ft (12-ft lane and 9-ft of outside shoulder).

The rolling sequence behind the paver included the initial or breakdown rolling with an 8 to 12 ton steel wheeled roller operating at 3 mph; the intermediate rolling with a Vibro-Plus roller operating statically with non-

vibrating passes at 5 mph; and the final rolling with another steel wheeled roller operating at 3 mph. To ascertain uniform compacting operations, rolling sequence, equipment, and personnel were the same throughout the compaction work.

All the asphaltic mixtures placed on the test area showed acceptable materials characteristics during mixing, spreading, compacting, and finishing. In that respect, no observable differences were found between Trinidad and conventional mixtures. Even when the resurfacing was completed, the new road surface showed similar overall appearance; but close examination revealed slight differences in surface texture and color. Trinidad resurfacing showed a coarser texture and lighter color than the conventional type.

During construction operations, Testing and Research personnel measured and recorded rolling temperatures at frequent intervals and took nuclear density readings at random locations in each test section. Regular traffic continued to move along the open lane while the work was in progress.

Construction Problems

After a nine-hour trip from the source of the fluxed Trinidad to the plant site, each shipment of Trinidad asphalt was found to be segregated. The Trinidad product (30 percent Trinidad and 70 percent conventional bitumen) shipped in 5,000-gal drums was no longer a uniform liquid-solids blend as required by the supplemental specifications (Appendix). The problem was caused by the particulate material (about 9.0 percent) which settled to the bottom of the shipping drum. To break up the sediment, compressed air at 120 lb/sq in. was applied for about a half-hour through the bottom inlet. After correcting the problem, the fluxed Trinidad was transferred to 10,000 gal storage tanks (two were available) equipped with low-speed, screw-type agitators. To assure uniform dispersion of all fine particles, the Trinidad asphalt required a 24-hour period of continuous heating and blending. This period was longer than that anticipated by the Department. Another problem was that in cold weather, with temperatures in the low 60's, Trinidad mixtures being placed at temperatures below 300 F resisted compaction with conventional rollers. This only occurred in a short section which required vibratory rolling to achieve proper densification.

Construction Costs

In making a valid cost comparison between pavement overlays or resurfacing jobs other cost factors beside construction costs must be estab-

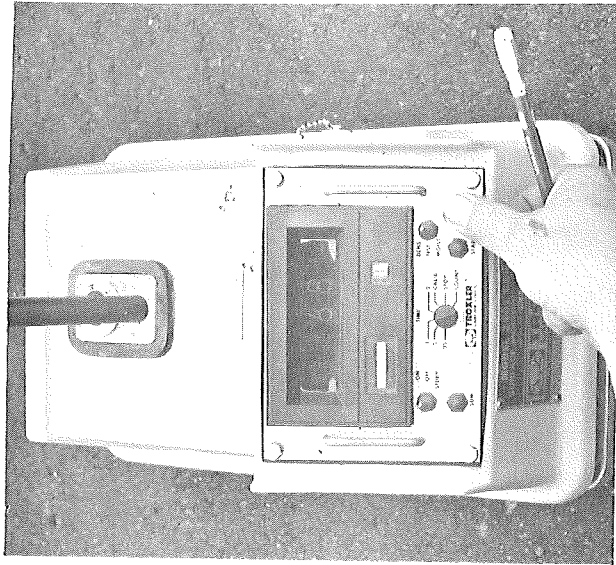
lished to determine the most economical construction. The additional cost factors should include motorists costs because of delays during overlaying work, interest rates, and future costs over some finite period of time because of routine maintenance or added overlay construction (1). Since these cost data are not available, only construction costs are included in the report.

In general, construction costs of bituminous concrete pavement cover the cost of materials, production, hauling or trucking, paving, overhead, and bidder's profit (2). For the experimental resurfacing work, construction costs were compiled by R. E. Oja, Project Engineer, and summarized in Table 2. Note that unit prices for Trinidad were 57 to 76 percent higher than those for conventional bituminous concrete.

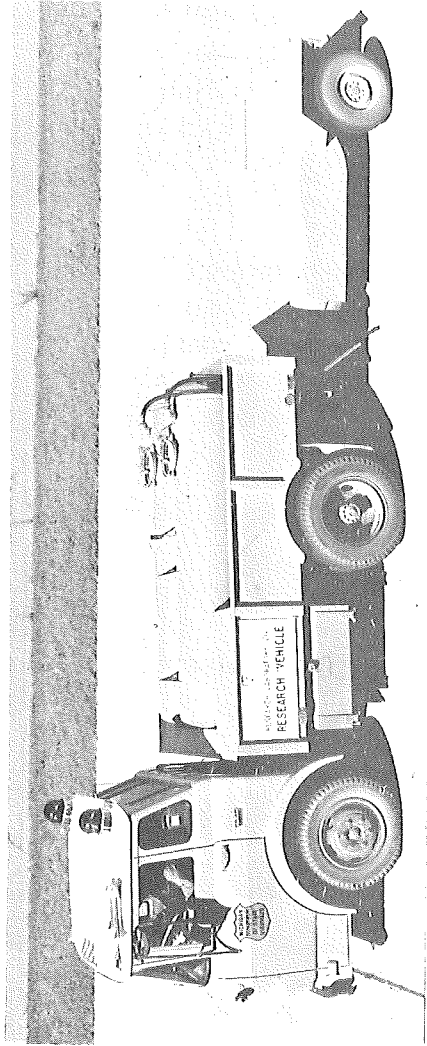
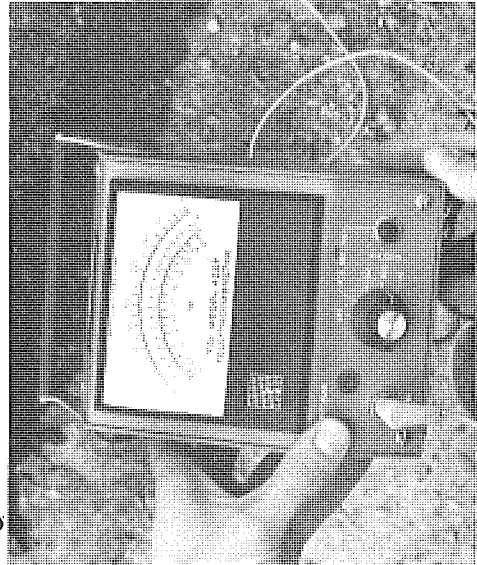
TABLE 2
COMPARATIVE CONSTRUCTION COSTS FOR BITUMINOUS
CONCRETE RESURFACING

Construction Project Mb 72013

Item	Construction Estimates		Construction Completed		
	Quantity, tons	Cost, dollars	Quantity, tons	Cost, dollars	Unit Price, dollars/ton
Bituminous Leveling Course 25A	7,832	119,829.60	7,854	120,166.20	15.30
Trinidad Leveling Course 25A	5,102	137,243.80	5,152	138,588.80	26.90
Bituminous Wearing Course Type C	2,080	35,776.00	2,096	36,051.20	17.20
Trinidad Wearing Course Type C	2,100	56,280.00	2,086	55,904.80	26.80
Bituminous Wearing Course Type M	7,231	133,773.50	7,360	136,160.00	18.50
Trinidad Wearing Course Type M	4,709	128,084.80	4,755	129,336.00	27.20



Battery-operated thermometer (sensed by probes).



Towing vehicle and skid trailer

Troxler nuclear density gauge, Model 2401.

Michigan's GM-Type Rapid Travel Profilometer.



Figure 6. Field Testing Equipment used on Construction Project Mb 72013/06140A, US 27 west of Houghton Lake.

FIELD TESTING

The main purpose of field testing for this project was to determine important properties, such as compaction, skid resistance, and riding quality of the finished pavement.

Compaction

During compaction, pavement temperatures were measured with a single probe, portable, battery operated thermometer (YSI Model 42SF) and in-place compacted densities were monitored at random locations with a Troxler nuclear density gage (Model 2401). Since the Department does not specify compacted density limits for bituminous concrete pavement, no attempt was made to control compaction with the density gage; rather the gage was used to monitor densities after rolling operations were completed. Field testing equipment used in this project is shown in Figure 6.

Skid Tests

Skid-resistance tests are friction measurements taken on wheel tracks of wetted roads by using a towing vehicle and a skid trailer (3).

The measuring system is operated on an electrically controlled cycle which first dispenses about 3.5 gal of water into the trailer wheeltracks (Fig. 6). Then, with the wheels locked, the trailer is dragged for approximately 60 ft by a towing vehicle at 40 mph. From this cycle of events, and the measured force required to pull the skid trailer, coefficients of wet sliding friction (wsf) are automatically obtained (3, 4, 5). At least three skid tests per pavement section are required to determine the average wsf value. In Michigan, skid test values are usually expressed as 40 mph coefficients of wet sliding friction. A wsf value determined from a highly textured concrete pavement would be expected to be 0.60 or higher. Wsf values of 0.20 or below might be as slippery as packed snow, and those below 0.07 are representative of a glare ice condition (6).

Riding Quality

Riding quality, as affected mainly by pavement smoothness or surface irregularities, is determined in Michigan by recording longitudinal profiles of a pavement surface. The General Motors Type Rapid Travel Profilometer is a complex measuring system equipped with a road-following wheel mounted underneath, a linear potentiometer, an accelerometer, a photocell, and other devices to trace and record an accurate profile of an outside wheel

TABLE 3
SUMMARY OF COMPACTION DATA
(Bituminous Concrete Pavement 4.12)

Item	2 ⁵ / ₄ A Leveling Course @ 130 lb/sq yd		Wearing Course					
			25A Type C @ 160 lb/sq yd		31A Type M @ 120 lb/sq yd			
	Trinidad 6.0%	Conven- tional 5.0%	Trinidad 6.0%	6.5%	Conven- tional 6.0%	Trinidad 6.0%	6.5%	Conven- tional 6.0%
No. of sections	8	4	2	2	2	4	4	4
No. of tests	97	88	14	20	32	49	47	92
Avg. density, pcf*	137.7	137.7	143.3	144.3	142.1	142.6	142.5	141.1
Rel. variation, percent**	2.3	1.8	1.6	1.2	1.0	1.2	1.5	0.9

* In-place compacted densities determined with a Troxler nuclear gage.

** Ratio of the standard deviation over the mean value.

path of a pavement (7, Fig. 6). From these road surface profiles, elevation changes are converted to the traditional roughness values in inches per mile. On the basis of riding quality, Michigan has traditionally classified surface roughness in three categories: "good" from 0 to 130, "average" from 131 to 174, and "poor" equal to or above 175 accumulated inches per mile.

Discussion of Results

In general, a detailed study of plant and field data and a close inspection of all operations indicated that the entire experimental project was kept under uniform, reasonable control during the construction period.

Compaction results as measured by the nuclear gage are summarized in Table 3 and shown graphically in Figures 10 through 13 in the Appendix. The compaction data indicated the following:

- 1) In-place compacted densities were higher for wearing course than for leveling course layers probably as a result of fewer air voids in the wearing course mixes and less rebound deflection of the top layer (8).

- 2) For leveling course sections, Trinidad and conventional resurfacing showed very little difference in field compaction; similarly with the wearing course sections. Although higher densities were found in the center than near the edges of the road, the relative variation of individual density tests fell within acceptable limits.

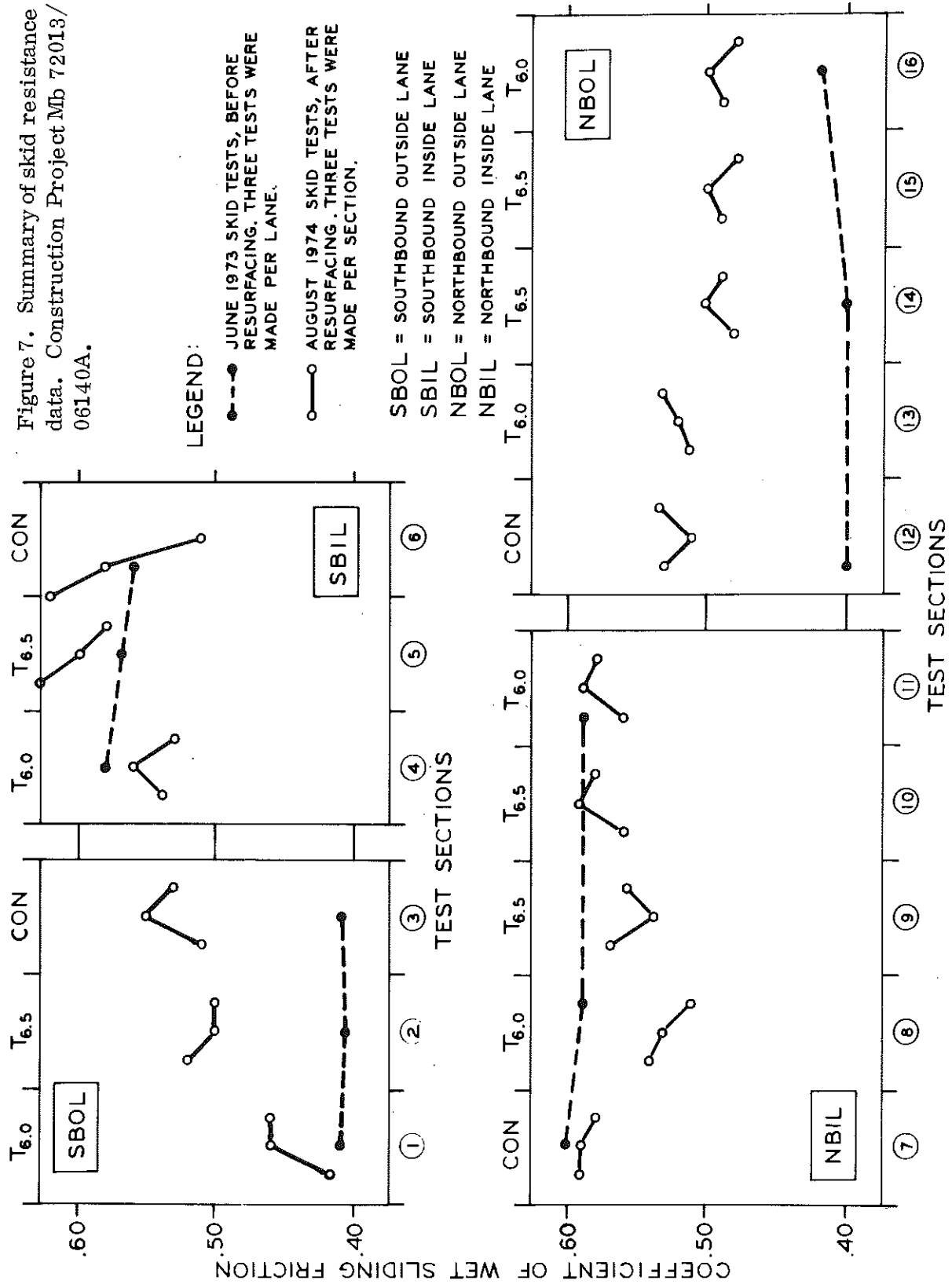
- 3) About 90 percent of all density results were obtained under breakdown or initial rolling temperatures ranging from 260 to 320 F. No specific trend for compacted densities was noted within such temperature range.

Figure 7 summarizes the skid test results obtained before and after resurfacing the test area. The skid data indicated the following:

- 1) After a 13-year service period, the old flexible pavement showed satisfactory friction levels. None of the lanes had average wsf values below 0.40

- 2) After resurfacing, both outside lanes showed a slight increase in skid resistance values averaging from 0.40 to 0.51 for the northbound outer lane and 0.41 to 0.49 for the southbound outer lane. On the other hand, the skid resistance level for both inside lanes showed no improvement perhaps because their wsf values were higher than those of the outside lanes before resurfacing.

Figure 7. Summary of skid resistance data. Construction Project Mb 72013/06140A.



3) Negligible differences in skid resistance levels were found between Trinidad and conventional sections; also between sections with 6.0 and 6.5 percent Trinidad asphalt.

Riding quality results in terms of accumulated vertical inches of displacement per mile of pavement (surface roughness) are summarized in Figures 8 and 9. These data, obtained before and after resurfacing the test area, indicated the following:

1) After a 13-year service period, the old flexible pavement provided adequate riding quality with average roughness values ranging from 139 to 149 accumulated inches per mile.

2) As shown in Figures 8 and 9, the old pavement after resurfacing showed an improved riding quality as follows: 59.3 percent improvement from 139 to 136 in./mile for the southbound outer lane; 96.2 percent improvement from 146 to 129 in./mile for the southbound inner lane; 74.1 percent improvement from 148 to 144 in./mile for the northbound inner lane; and 92.6 percent improvement from 149 to 136 in./mile for the northbound outer lane. Thus, on the basis of Departmental standards, 75 percent of the overall improvement in riding quality occurred within the limits considered as average surface roughness. The remaining 25 percent overall improvement was from average to good surface roughness.

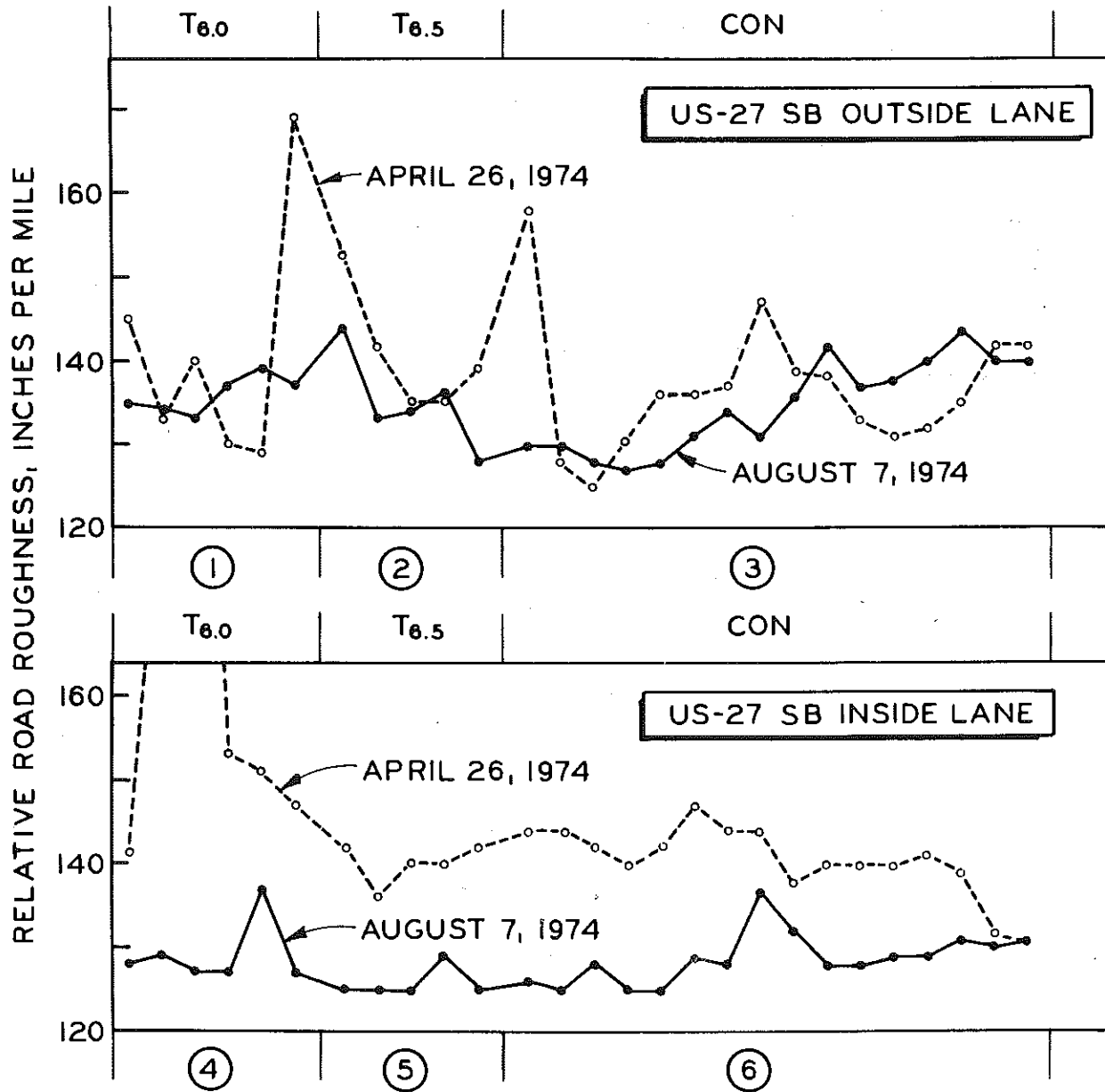
3) Insignificant differences in riding quality levels were found between Trinidad and conventional resurfacings; also between resurfacings with 6.0 and 6.5 percent Trinidad asphalt.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1) As indicated earlier, Trinidad resurfacing covered cracking conditions of relatively greater severity than that covered with conventional asphalt. If Trinidad resurfacing reduces or eliminates reflection cracking under such conditions, certainly it should do well under nearly any conditions.

2) Very few departures from the standard specifications were necessary during the resurfacing work including mix design, plant production, and paving operations. Also, regular inspection, control practices, and workmanship were satisfactory throughout the experimental project.



LEGEND:

----- ROUGHNESS BEFORE RESURFACING IN INCHES PER MILE.

———— ROUGHNESS AFTER RESURFACING IN INCHES PER MILE.

○ — TEST SECTIONS

Figure 8. Summary of roughness data. Construction Project Mb 72013/06140A. Each test point represents approximately 1,000 lin ft of pavement.

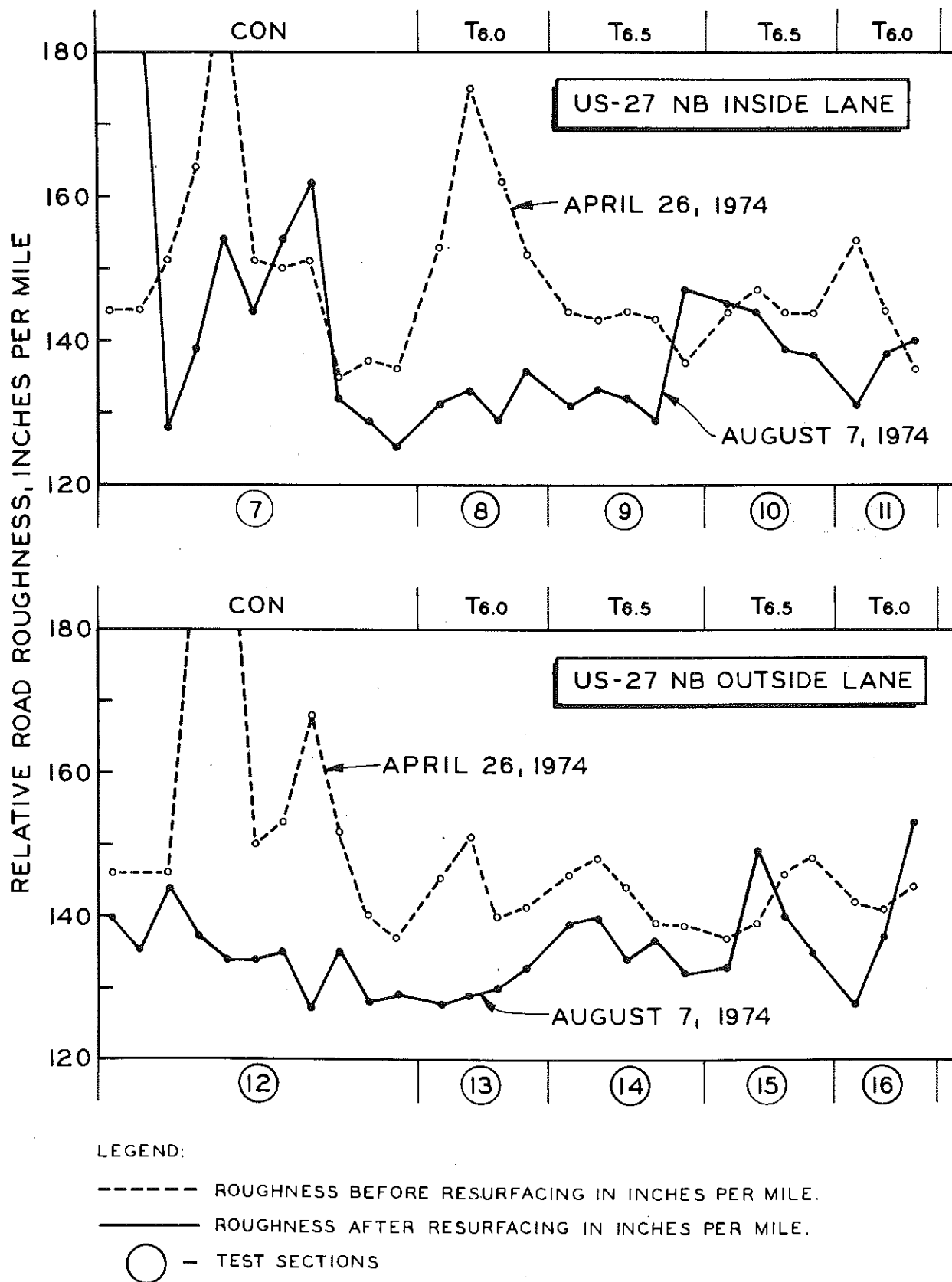


Figure 9. Summary of roughness data. Construction Project Mb 72013/06140A. Each test point represents approximately 1,000 lin ft of pavement.

3) A nine-hour trip from the source of the fluxed Trinidad to the plant site caused a segregation problem in each shipment. Settled particulate material required compressed air to break it up and keep fine particles in suspension.

4) Though, in general, all the asphalt mixtures presented no difficulties in spreading, compacting, and finishing with conventional equipment; in cold weather with temperatures in the low 60's, Trinidad mixtures being placed at temperatures below 300 F caused some compaction problems, such as surface ripples or waves next to the roller. Vibratory rolling was required in a short Trinidad section to achieve proper compaction.

5) Construction costs for Trinidad asphalt sections were up to 76 percent higher than those for conventional sections.

6) Initial performance characteristics of Trinidad and conventional resurfacings showed very small differences in surface texture, color, compaction or densification, skid resistance, and riding quality. For all practical purposes, all the test areas were about equal in performance characteristics. Thus, at this point, the only chief difference between the two asphaltic materials was the initial construction cost.

Recommendations

If the Department contemplates further resurfacing jobs with Trinidad asphalt; three major points should be considered:

1) Better blending arrangements in trucks transporting fluxed Trinidad asphalt to the plant site are needed. The existing air agitating system in the shipping drum was inoperative while the truck was in motion. Such faulty agitating design caused about 30 minutes delay in plant operations for each delivery of Trinidad.

2) On cold days, placing and compacting Trinidad mixtures at rolling temperatures below 300 F, should not be attempted with conventional equipment. Vibratory compaction is required under such conditions. Conventional equipment operates properly for rolling temperatures above 300 F.

3) Since it is claimed that, as the pavement ages, Trinidad asphalt should give more quality performance per dollar invested than conventional asphalts, seasonal surveys of the test areas will be continued for at least five years. Further, after five years service it is planned to estimate surface durability in resisting cracking, deformation, and other pavement failures.

Future Work

Seasonal surveys and field inspections of the experimental project will continue until the resurfaced area is old enough to estimate the full potential of Trinidad asphalt as a smooth-riding, anti-skid, durable, and economical pavement as compared with conventional bituminous construction. Further, climatological data from the Houghton Lake Airport, about 15 miles from the project site, will be periodically studied and related to pavement performance. Also, photographic records of changes in surface texture, and survey maps showing locations, extent, and severity of progressive cracking will be maintained for comparative evaluation. Subsequent progress reports will be written as needed.

REFERENCES

1. "Pavement Rehabilitation, Materials and Techniques," Highway Research Board, NCHRP Report 9, pp 25-30, 1972.
2. "Dollars and Sense of Hot Mix Production," CMI Systems, CMI Corporation.
3. "Equipment for Measuring Pavement Skid Resistance," Research Laboratory Report No. R-747, February 1971.
4. "Summaries of Michigan Pavement Skid Resistance," 1965 Test Program, Research Laboratory Report No. R-585, June 1966.
5. "Summaries of Michigan Pavement Skid Resistance," Research Laboratory Report No. R-831, September 1972.
6. "Summaries of Michigan Pavement Skid Resistance," Research Laboratory Report No. R-944, October 1974.
7. Darlington, J. R., "Evaluation and Application Study of the General Motors Corporation Rapid Travel Profilometer," Research Laboratory Report No. R-731, October 1970.
8. Graham, Malcolm D., et al, "Pavement Density - What Influences It," Proceedings, Volume 34, the A of A. P. T., February 15, 16, 17, 1965, pp 286-308.

APPENDIX

Special Provision
For
Trinidad Asphalt Bituminous Concrete Pavement

Description

This work shall consist of constructing a bituminous concrete surface using a fluxed Trinidad asphalt cement as the bituminous material in the mixture in accordance with the requirements for Bituminous Concrete Pavement, 4.12 of the Standard Specifications with the following exceptions and additions.

Material

The bituminous material for the mixture shall be a Trinidad asphalt cement produced by fluxing Trinidad asphalt with petroleum asphalt cement to produce a blended asphalt cement meeting the following requirements.

Specific Gravity, 25/25C	1.075+
Penetration @ 25C, 100g, 5 sec.	85 to 100
Ductility at 25C, cm	60+
Flash Point, Cleveland Open Cup, deg C.	175+
Loss on heating 163C, 50g, 5 hrs (percent)	1.0-
Penetration of residue at 25C as compared to penetration before heating (percent of original)	70+
Solubility in Trichloroethylene	84+
Ash (percent)	7.5 to 16.0

The bituminous material shall be free from water, thoroughly blended, and ready for use when received on the site of the work. No blending will be permitted on the job.

Equipment

The bituminous material for the mixture contains approximately 10 percent particulate material which is extremely fine (mostly less than 100 microns). It is advantageous to the contractor that the bituminous material be delivered in tanks which provide suitable agitation to keep the particulate material in suspension and will deliver the bituminous material to the job in a temperature range of 380 F to 390 F.

The asphalt storage tanks shall be equipped with an adequate system of agitation to keep the particulate material in suspension which may be one of the following:

- a. A mechanical mixer in the storage tank.
- b. A recirculating system with discharge pipe diametrically opposite the bottom suction inlet and at an elevation at least 1/4 of the maximum working level of the tank.
- c. An approved air spider agitating system.

The asphalt storage tank shall have a sufficient capacity above the normal working level to accept one delivery tank of material.

Construction Methods

In the preparation of the bituminous concrete mixture the agitating system in the storage tanks shall be operating at all times to insure the homogeneous consistency of the bituminous material. In the event of shutdowns the storage tank shall be heated to operating temperature and the agitating system operated for at least one hour prior to preparing the mixture.

Although there are no anticipated exceptions or additions to the other provisions for construction methods the Contractor will be expected to make reasonable adjustments to allow for the uniqueness of the Trinidad bituminous material and the experimental nature of the work.

Method of Measurement

Trinidad Bituminous Concrete Leveling, Trinidad Bituminous Concrete Wearing Course Type C, and Trinidad Bituminous Concrete Wearing Course Type M will be measured by weight in tons.

Basis of Payment

The completed work as measured for Trinidad Asphalt Bituminous Concrete Pavement will be paid for at the contract unit prices for the following contract items (pay items).

Pay Item	Pay Unit
Trinidad Bituminous Concrete Leveling Course 25A	Ton
Trinidad Bituminous Concrete Wearing Course Type C	Ton
Trinidad Bituminous Concrete Wearing Course Type M	Ton

5-25-73

6-18-73

8-3-73

10-23-73



CONTRACT NUMBER
REPORT NUMBER

CHICAGO TESTING LABORATORY, INC.

FOUNDED 1912
(312) 498-6400

GENE ABSON, P.E. (1897 1963) 3360 COMMERCIAL AVENUE; NORTHBROOK, ILLINOIS 60062
CONWAY C BURTON, P.E.
WARD K. PARR, P.E.

ASPHALT CEMENT

TO
Great Lakes Asphalt Inc.
RR 1
Zionsville, Indiana 46077

DATE June 4, 1974
LABORATORY NUMBER 51947
DATE SAMPLED
DATE RECEIVED 5-28-74
SUBMITTED BY Great Lakes
SOURCE

INTENDED USE

TYPE AC-Trinidad
Indiana ATB-3
LOT NUMBER
QUANTITY - GALS. AT 60°F
SEAL NUMBER CTL

"All tests are conducted in accordance with the latest ASTM or AASHTO Test Methods where applicable"

PENETRATIONS:

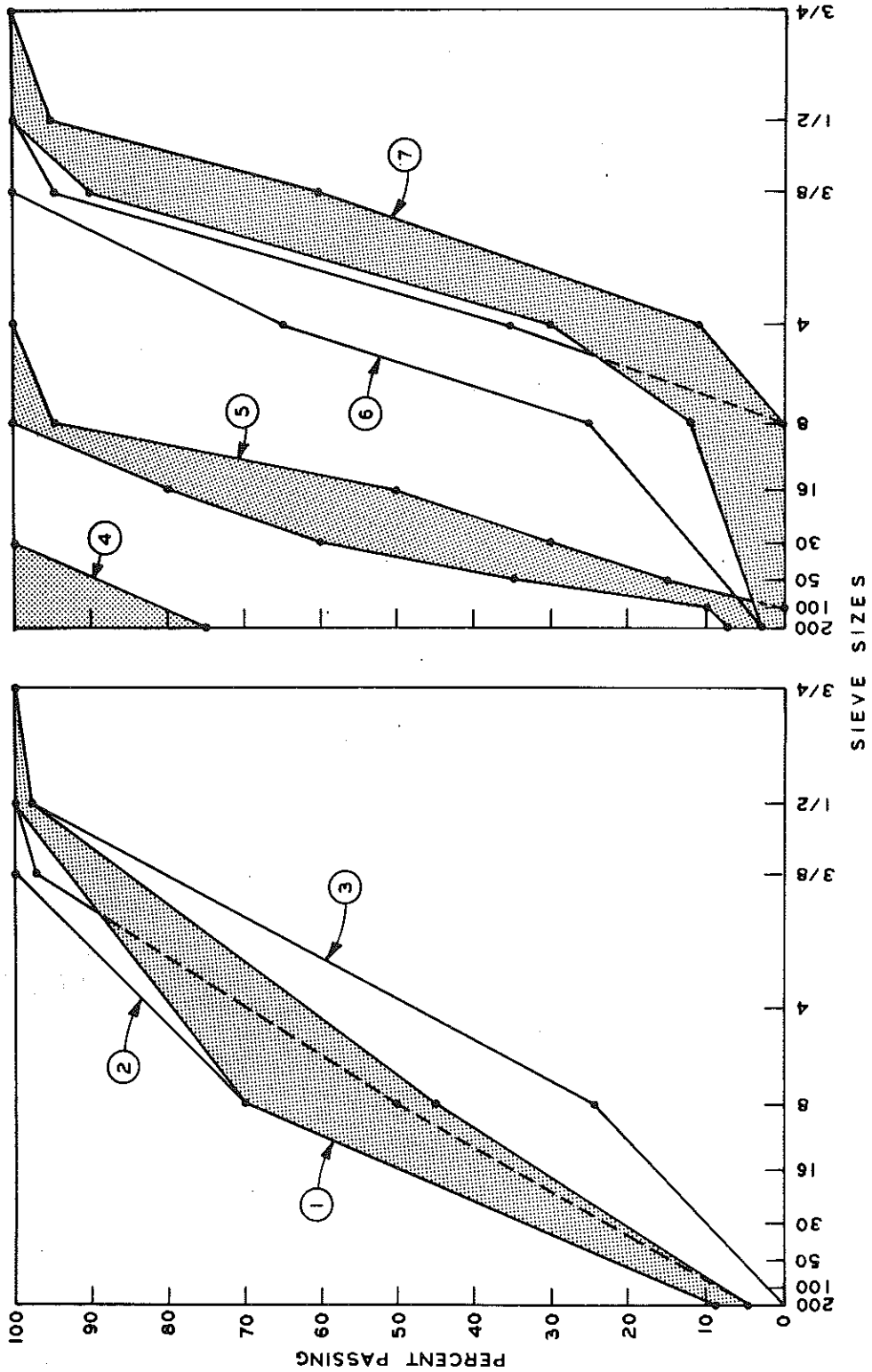
AT 77°F (100 GMS. 5 SEC.)	97
32°F (200 GMS. 1 MIN.)	
115°F (50 GMS. 5 SEC.)	
VISCOSITY, FUROL AT 275°F	(Sec)
VISCOSITY, KINEMATIC AT 275°F	(cSt) 277
VISCOSITY ABSOLUTE @ 140°F	(P)
DUCTILITY AT 77°F, 5/60	(cm) 137
DUCTILITY AT °F	(cm)
SOFTENING POINT, R & B	(°F) 119
SPECIFIC GRAVITY AT 77°F	1.096
EQUIV. LBS./GAL. AT 60°F	9.16
FLASH POINT, C.O.C.	(°F) 550+
SOLUBILITY IN Benzene	(%) 85.98
SPOT TEST - STANDARD NAPHTHA	Positive
NAPHTHA - 10% XYLENE	
HEPTANE - 35% XYLENE	
LOSS, 5 HR. () REG. () THIN FILM	(%) 0.02
PENETRATION AFTER, AT 77°F	87
(%) OF ORIGINAL	89.7
Solubility in CCl ₄	(%) 88.35
Ash	(%) 8.75

The spot test result is not applicable due to contamination of spot by suspended mineral matter in Trinidad material.

2-Great Lakes
cb

CHICAGO TESTING LABORATORY, INC.

BY *Ward K. Parr*



- LEGEND:
- ① 25A TYPE C WEARING COURSE
 - ② 31A TYPE M WEARING COURSE
 - ③ 25A LEVELING COURSE
 - ④ MINERAL FILLER
 - ⑤ 3FS SAND
 - ⑥ 31A COARSE AGG.
 - ⑦ 25A COARSE AGG.

Gradation curves showing aggregate specification limits required by current MDSHT standards.

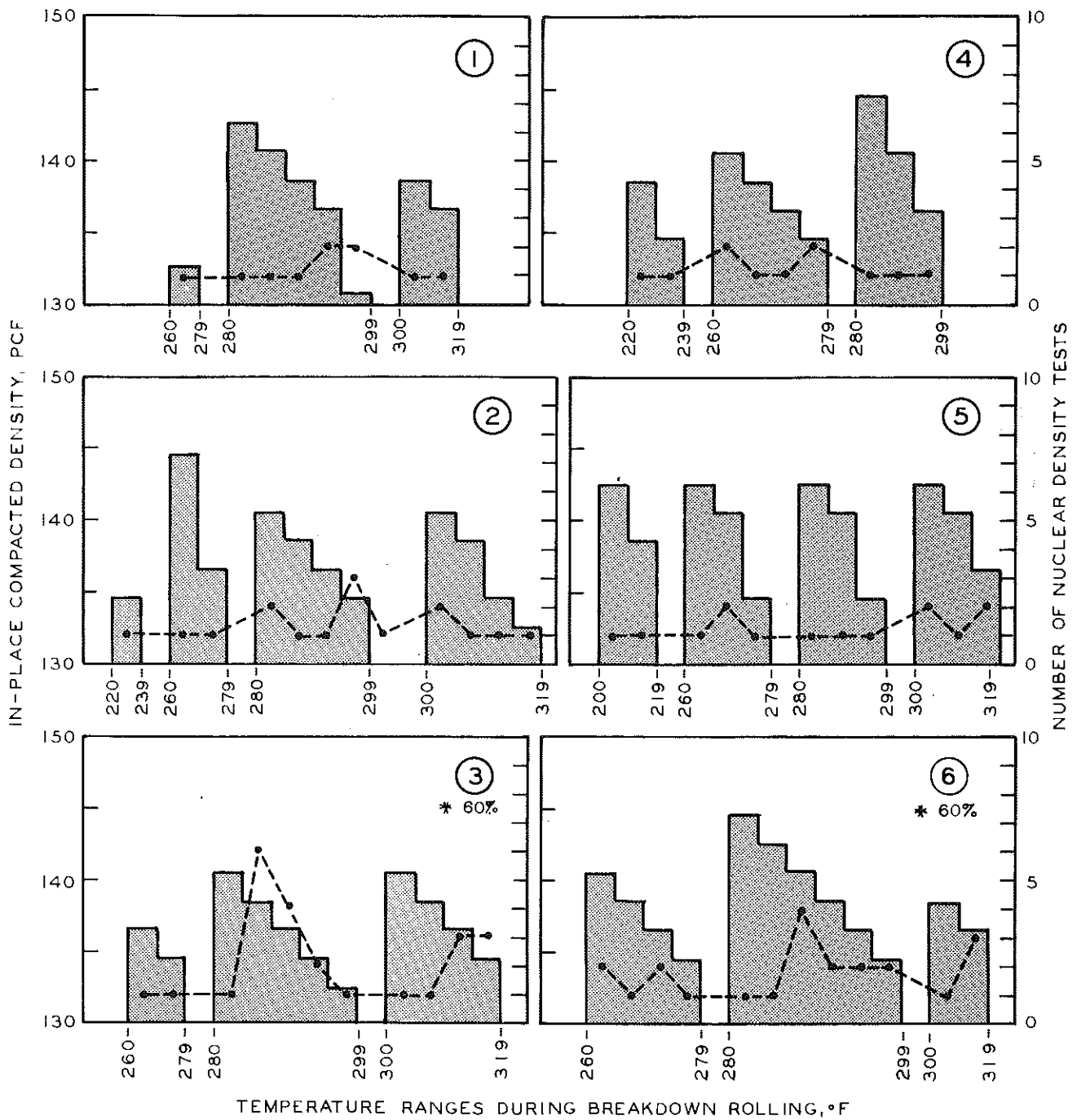


Figure 10. Field density results after compacting the bituminous concrete leveling course. Southbound US 27, Construction Project Mb 72013/06140A.

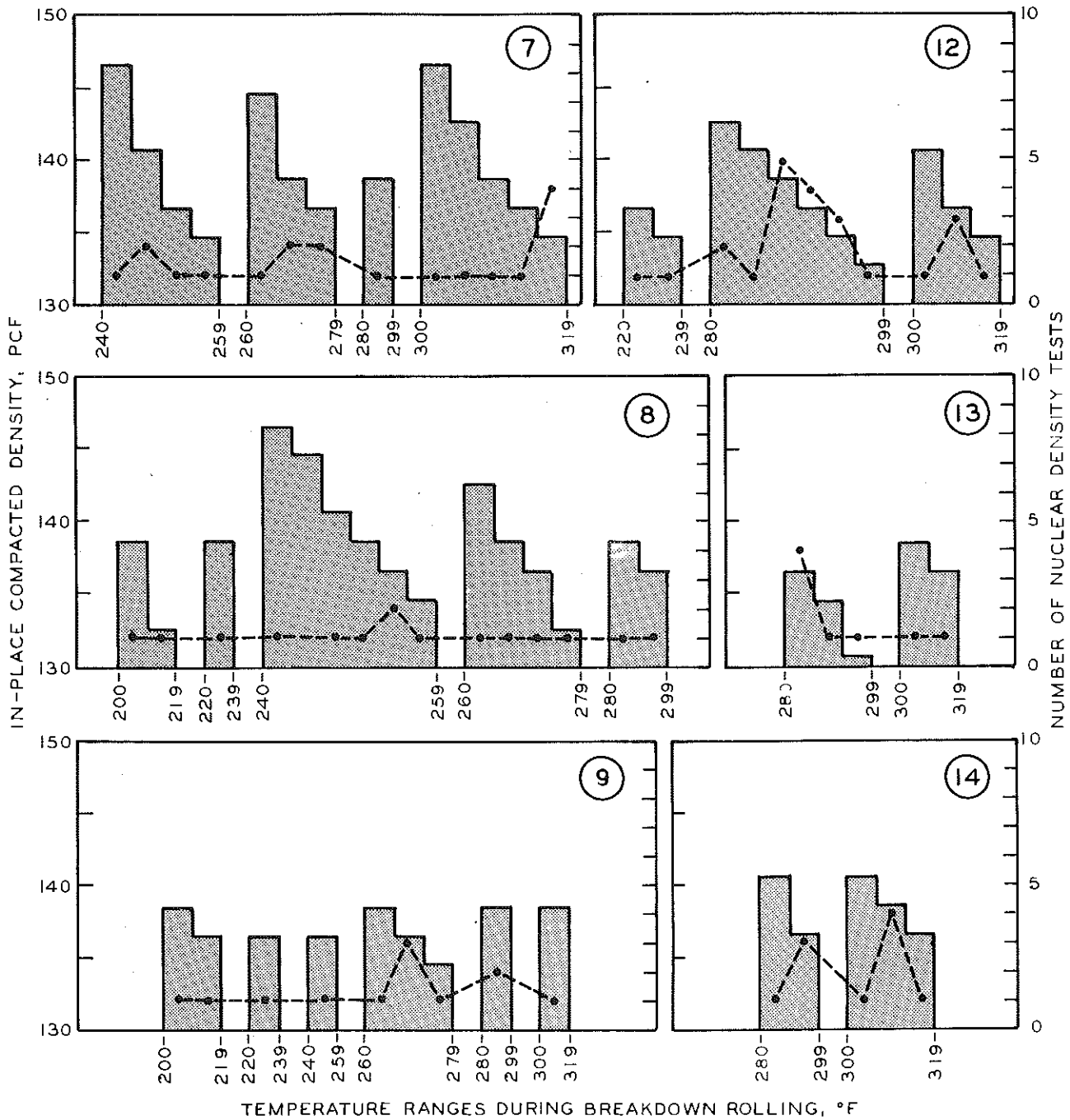


Figure 11. Field density results after compacting the bituminous concrete leveling course. Northbound US 27, Construction Project Mb 72013/06140A.

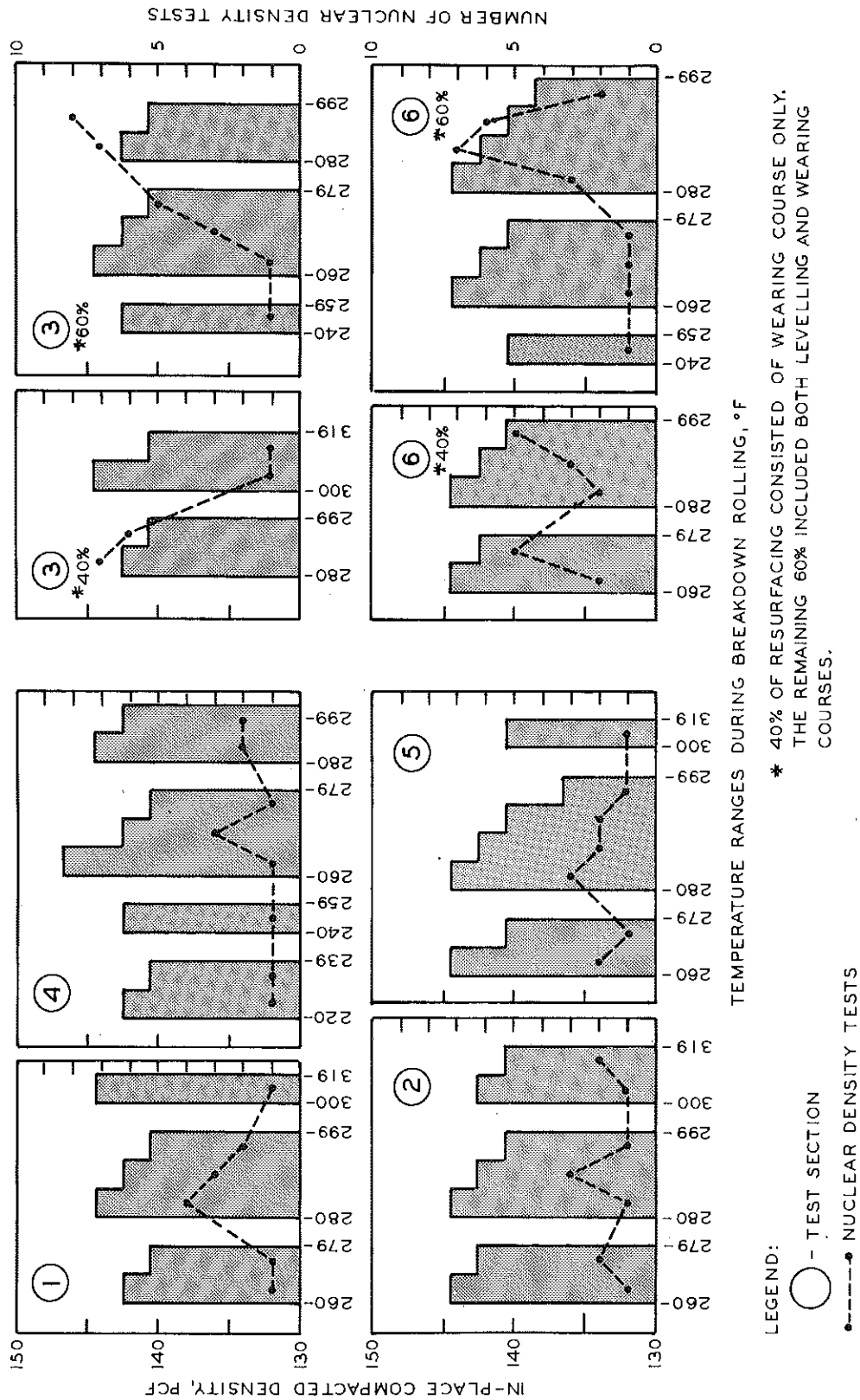


Figure 12. Field density results after compacting the bituminous concrete wearing course. Southbound US 27, Construction Project Mb 72013/06140A.

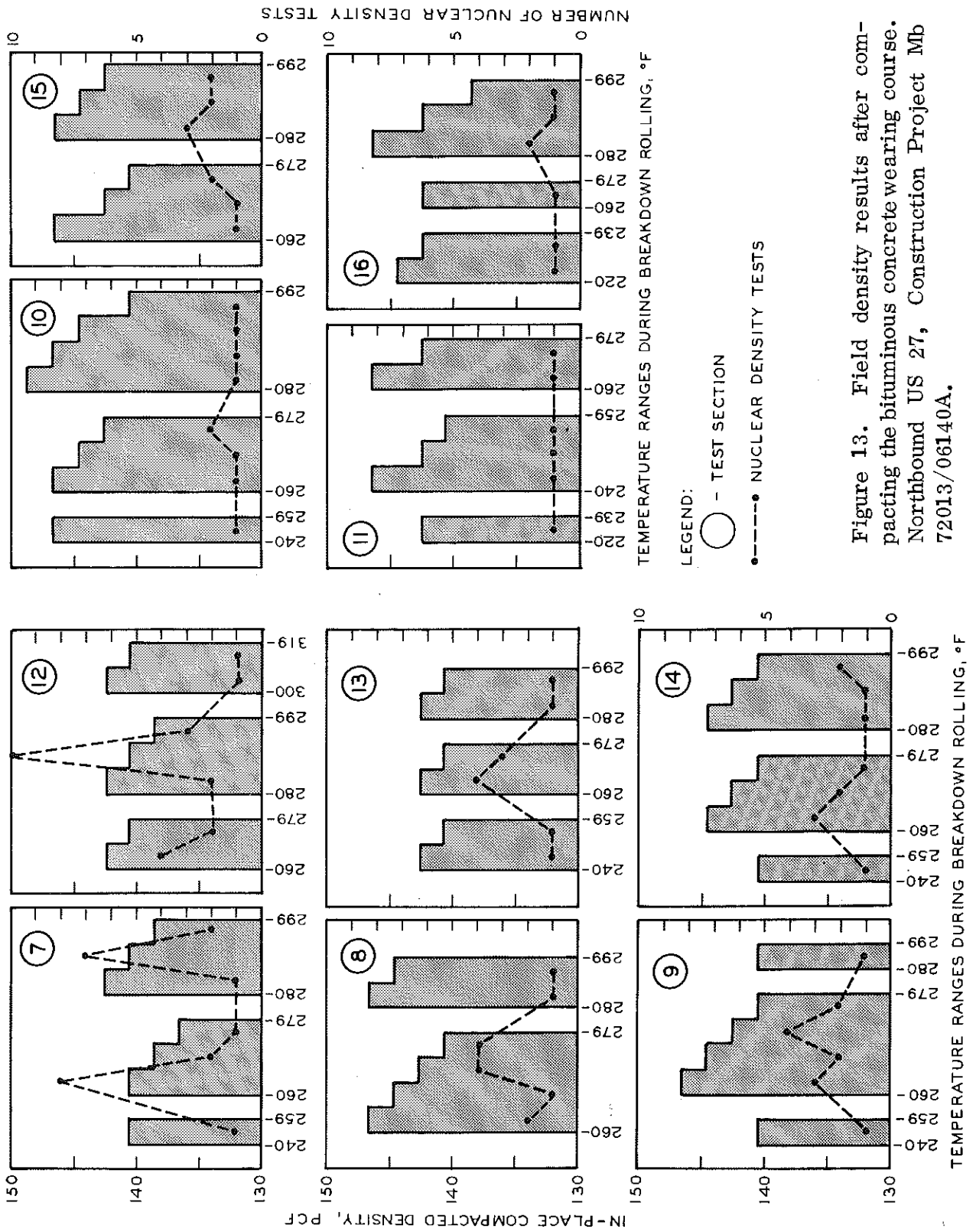


Figure 13. Field density results after compacting the bituminous concrete wearing course. Northbound US 27, Construction Project Mb 72013/06140A.