

CONCRETE CAPPING STUDY--FINAL REPORT
Goesbeck Highway (Project F 50-7, C5)
US 127 (Project F 33-54, C2)

LAST COPY
DO NOT REMOVE FROM LIBRARY



MICHIGAN DEPARTMENT OF STATE HIGHWAYS

CONCRETE CAPPING STUDY--FINAL REPORT
Groesbeck Highway (Project F 50-7, C5)
US 127 (Project F 33-54, C2)

C. A. Zapata

Research Laboratory Section
Testing and Research Division
Research Projects 52 F-25; 53 F-29
Research Report No. R-763

Michigan State Highway Commission
Charles H. Hewitt, Chairman; Wallace D. Nunn, Vice-Chairman;
Louis A. Fisher; Claude J. Tobin; Henrik E. Stafseth, Director
Lansing, March 1971

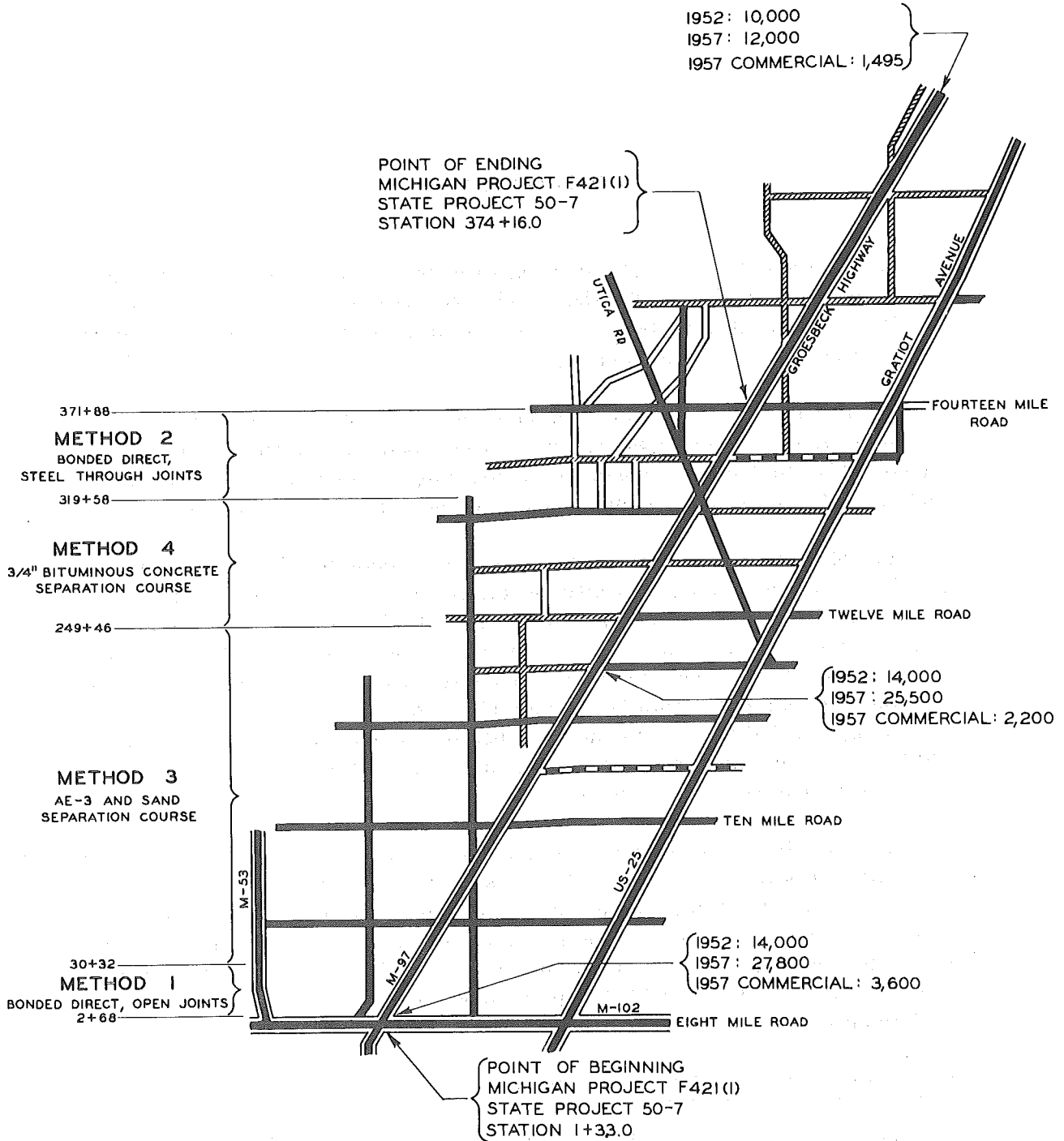


Figure 1. Plan view of capping test areas showing traffic volumes.

INTRODUCTION

Several progress reports dealing with the results from these two projects have already been published. The purpose of this report is to summarize what has already been reported and present conclusions concerning portland cement concrete capping.

Portland cement concrete resurfacing, or capping, is sometimes used for improving pavements where an existing road and facilities can be salvaged. The thickness of concrete resurfacing depends upon the condition and strength of the old pavement and upon the expected traffic volume.

In 1948, the Portland Cement Association recommended bonded interface between new capping and old concrete for resurfacing under 3 in. thickness (1). Bonded interface was not required when concrete capping was 3 in. or more in thickness. They also stated that intimate contact between new and old concrete was the important factor in securing bond. This meant that the original base must be clean and slightly damp at the time of resurfacing and that the fresh concrete should flow into all depressions in the old base. Then, good consolidation must be attained to assure good contact between the two adjacent surfaces.

In 1952, the Department conducted a concrete capping study on the Groesbeck Highway near Detroit to evaluate the effectiveness of several resurfacing methods in reducing transverse cracking of concrete slabs. In 1953, the Department began another concrete capping study with varying concrete slab lengths and resurfacing methods. The test site was 1.2 miles of southbound roadway on US 127 (four-lane divided highway) south of Holt in Ingham County.

Concrete Capping on Groesbeck Highway

The test site is 7.1 miles of two-lane highway on M 97 between Eight Mile Rd and Fourteen Mile Rd near Detroit (Fig. 1). In 1952, just before resurfacing, the old road carried an average daily traffic of 14,000 vehicles. The experimental design of this project is shown in Table 1. Concrete capping method and thickness were the major variables. Number of replicates and length of test sections were different for each combination of these main variables.

TABLE 1
EXPERIMENTAL DESIGN, CONCRETE RESURFACING,
GROESBECK HIGHWAY

(Number of replicates were different for each
combination of capping method and thickness)

Concrete Capping Method	Concrete Capping Thickness, in.					
	5	5-1/2	6	6-1/2	7	7-1/2
Method 1 Direct bond, open joints	3 replicate sections	2 replicate sections	1 section	none	none	none
Method 2 Direct bond, steel through joints	1 section	2 replicate sections	3 replicate sections	1 section	1 section	none
Method 3 AE-3 and sand separation course	3 replicate sections	6 replicate sections	7 replicate sections	3 replicate sections	6 replicate sections	none
Method 4 3/4-in. bit. conc. separation course	1 section	1 section	3 replicate sections	1 section	1 section	1 section

The old concrete pavement consisted of two different projects: Project 50-07, C2, constructed in 1928, was 20 ft wide with a 10-8-10 in. cross-section and extended from Eight Mile Rd to Utica Rd; Project F 50-07, C3, constructed in 1930, was 20 ft wide with a 10-9-10 in. cross-section and extended from Utica Rd to Fourteen Mile Rd. The original pavement was badly scaled and cracked; most transverse joints were covered with bituminous patches. In July 1952 the old pavement was widened and resurfaced as shown in Figure 2. About 1.5 miles of concrete resurfacing was bonded to the original pavement using Methods 1 and 2 (Table 1) and about 5.5 miles were unbonded as described in Methods 3 and 4.

In this project, an attempt was made to test and evaluate four different resurfacing methods with six different capping thicknesses. The effects of variables such as condition of old pavement and distribution of steel reinforcement were not considered in this study. The four resurfacing methods included in this study, and shown in Figure 1, were as follows:

Method 1

From station 2+68 to 30+32 (2,764 ft) the concrete capping was bonded directly to the existing pavement. Six test sections, or replicates, were

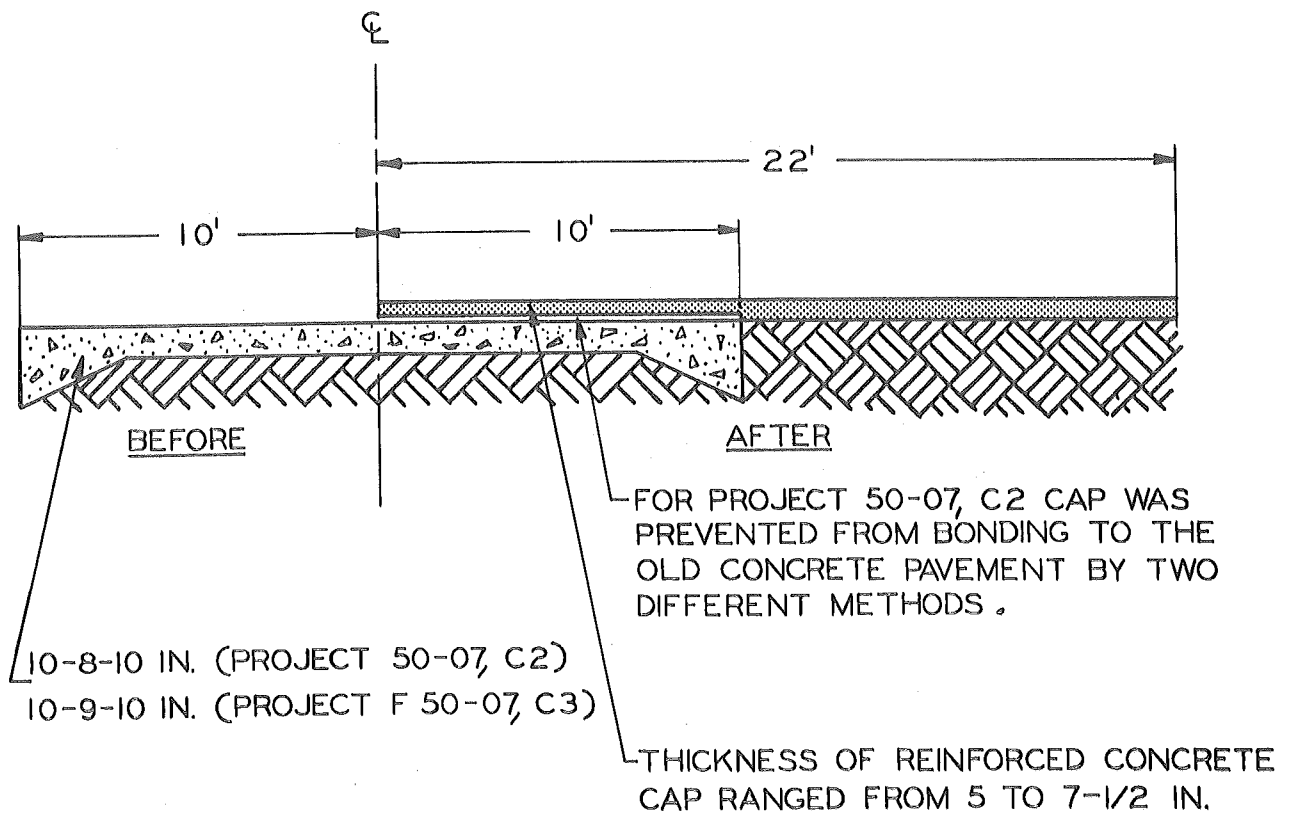
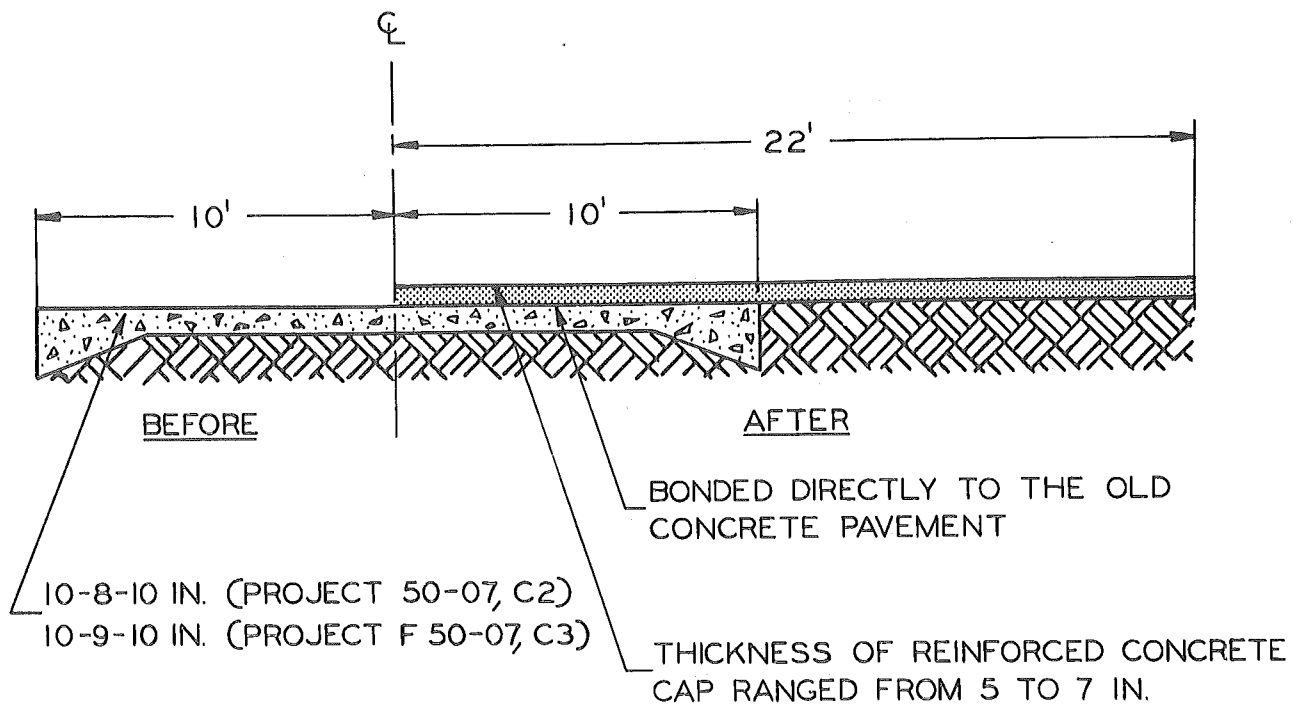


Figure 2. Groesbeck Highway concrete pavement widening and resurfacing.

used ranging from 269 to 700 ft long with each test section having a 5 to 6 in. capping thickness. Welded wire mesh weighing 79.6 lbs per 100 sq ft was used as reinforcement between transverse joints.

Method 2

From station 319+58 to 371+88 (5,230 ft), the concrete was bonded directly to the old pavement as in Method 1, but it was classified as Method 2 because of a construction error of extending the steel reinforcement across transverse joints. Eight test sections or replicates were used ranging from 291 to 1,490 ft long with cap thicknesses varying in 1/2-in. increments from 5 to 7 in.

Method 3 (Standard or Regular Procedure)

From station 30+32 to 249+46 (21,914 ft), the possibility of a bond between new and old concrete was eliminated or reduced by applying, as a breaker layer, a mixture of 0.25 gal of asphalt emulsion AE-3 and 40 lbs of sand per sqyd. Twenty-five test sections or replicates ranging from 151 to 2,460 ft long with cap thickness varying in 1/2-in. increments from 5 to 7 inches were used. These test sections were reinforced with wire mesh as in Method 1.

Method 4

From station 319+35 to 249+46 (6,989 ft), a 3/4 in. bituminous concrete leveling course was applied as a breaker layer to separate the concrete capping from the old pavement.

Eight test sections or replicates ranging from 298 to 1,205 ft long with cap thickness varying in 1/2 in. increments from 5 to 7-1/2 in. were used. The test sections were reinforced with wire mesh as in Method 1.

The first Progress Report (2) dealing with this project included the following experimental data:

a) A soil study after the old pavement was resurfaced, including general soil characteristics, field and laboratory densities, percent compaction, percent moisture, and core strengths of resurfaced pavement.

b) A pavement condition survey, which listed average number of cracks per concrete slab after resurfacing but before the new pavement was opened to normal traffic.

Based on these results, the report concluded that the two unbonded capping techniques (Methods 3 and 4) showed better cracking control than the direct bonded type (Methods 1 and 2).

The second and third Progress Reports (3, 4) gave the following information:

a) Average number of cracks per slab for the years 1952, '53, '55, '56, '58, and 1959 and relative cracking for concrete capping Methods 1, 2, and 4 compared with conventional (Method 3) capping.

b) A 1959 condition survey of repair patches placed in each of the four different capping method areas.

c) Average 1960 roughness for the four differently capped areas. Again, Progress Report No. 3 concluded that unbonded capping (Methods 3 and 4) showed less cracking formation than bonded (Methods 1 and 2). It concluded also that the greater the cap thickness the more effective the concrete resurfacing in reducing cracking.

The same report acknowledged certain inconsistencies and contradictions in the results; possibly caused by uncontrolled variations not considered in this study such as condition of old pavement, length and thickness of capped sections, and distribution of steel reinforcement (3).

Concrete Capping on US 127

The test site was about 1.2 miles of southbound roadway on US 127, a four-lane divided highway south of Holt in Ingham County (Fig. 3). In 1953, before concrete capping, the old pavement carried an average daily traffic of 6,900 vehicles.

In this project an attempt was made to determine the relative effectiveness of three different unbonded resurfacing methods combined with four different slab lengths.

The existing unreinforced concrete pavement (Project 33-27, C3) constructed in 1926 was 20 ft wide with 7-in. uniform thickness and 1-in. expansion joints at 100-ft intervals without load transfer. The old pavement, prior to concrete capping, was badly scaled and cracked with bituminous patches covering most of the transverse joints. In 1953, about 1.2 miles of existing pavement were widened and resurfaced as shown in Figure 4. A minimum concrete capping thickness of 6 in. was placed over the five sections under observation.

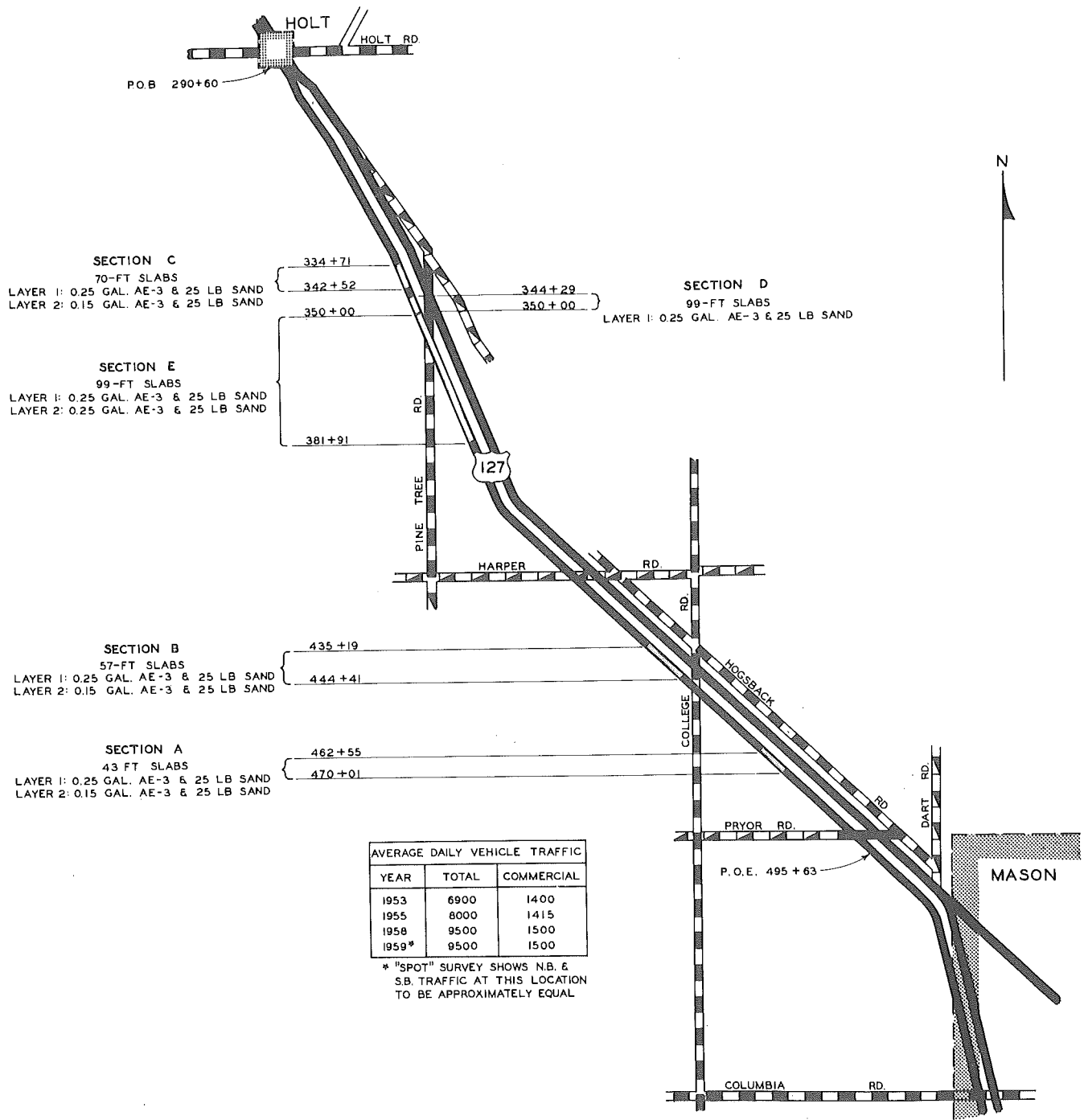


Figure 3. Plan view of capping test areas with traffic volumes.

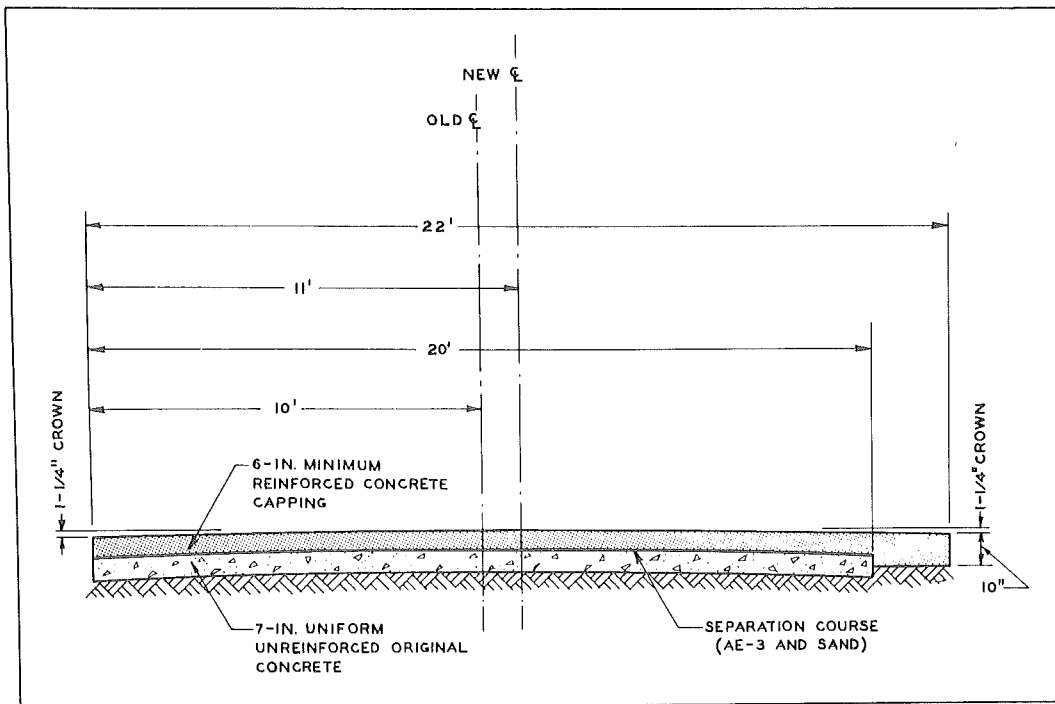


Figure 4. US 127 concrete pavement widening and resurfacing.

The five test sections were as follows:

Section A - From station 462+55 to 470+01 (746 ft), two applications of asphalt emulsion AE-3 mixed with sand were used to separate the concrete capping from the old pavement. Application 1 was composed of 0.25 gal AE-3 and 25 lb sand per sq yd; Application 2 consisted of 0.15 gal AE-3 and 25 lb sand per sq yd. Mesh-reinforced concrete slabs were 43 ft long with no load transfer across the joints.

Section B - From station 435+19 to 444+41 (922 ft), the two applications for bond breaking were the same as Section A. However, reinforced concrete slabs were 57 ft long with no load transfer across the joints.

Section C - From station 334+71 to 342+52 (781 ft), Application 1 was the same as Section A; Application 2 was a mixture of 0.15 gal AE-3 and 25 lb sand per sq yd. Reinforced concrete slabs were 70 ft long with no load transfer across the joints.

Section D - From station 344+29 to 350+00 (571 ft), a single course as in Application 1 of Section A was used. Reinforced concrete slabs were 99 ft long with no load transfer across the joints.

Section E - From station 350+00 to 381+91 (3,191 ft). The two applications for bond breaking had the same composition as Application 1 of Section A. Reinforced concrete slabs were 99 ft long with no load transfer across the joints.

The experimental design of this project provided 17 transverse joints for Section A, 18 for Section B, 11 for Section C, 6 for Section D and 33 joints for Section E.

The first two Progress Reports (5, 6) dealing with this project included the following results:

- a) Number of cracks per mile for 1953, '57, '59, and 1960 compared with test sections, slab lengths, and unbonded capping methods.
- b) A 1960 condition survey of joint seal failures for each slab length and each unbonded capping method.
- c) Average roughness.

The following conclusions are quoted from the second Progress report:

After nearly eight years of service, Section E with 99-ft slabs over a two-layer separation course is giving the best overall performance of the five capping test sections, when all performance factors are considered.

By the same performance standards, the poorest capping is the 70-ft slab section (Section C), with the 99-ft slabs over a one-layer separation course (Section D) only slightly better.

In general, overall performance of all sections has been relatively good. This is particularly true in comparison with other experimental concrete capping projects, such as the sections built in 1952 on the Groesbeck Highway (M 97) and most recently reported in Research Report 331 (1960).

The fact that some capped portions of this project have better riding qualities than 9-in. standard concrete pavement built at the same time indicates that capping for improvement of older concrete pavements is feasible and practical in certain situations.

On the other hand, the same report again acknowledged that the results may be affected by the condition of old pavement underlying the capped sections. The degree of distress of the old pavement was not considered to be an important variable in this study.

TABLE 2
ROUGHNESS DATA TAKEN IN 1960 AND 1968
FOR BOTH CONCRETE CAPPING PROJECTS

Capping Method	Roughness data for Groesbeck Highway, in./mi.*					
	April 1960			May 1968		
	NB	SB	Avg.	NB	SB	Avg.
1	172	201	186	248	276	262
2	175	172	174	268	260	264
3	170	187	178	253	268	261
4	169	166	168	229	242	236

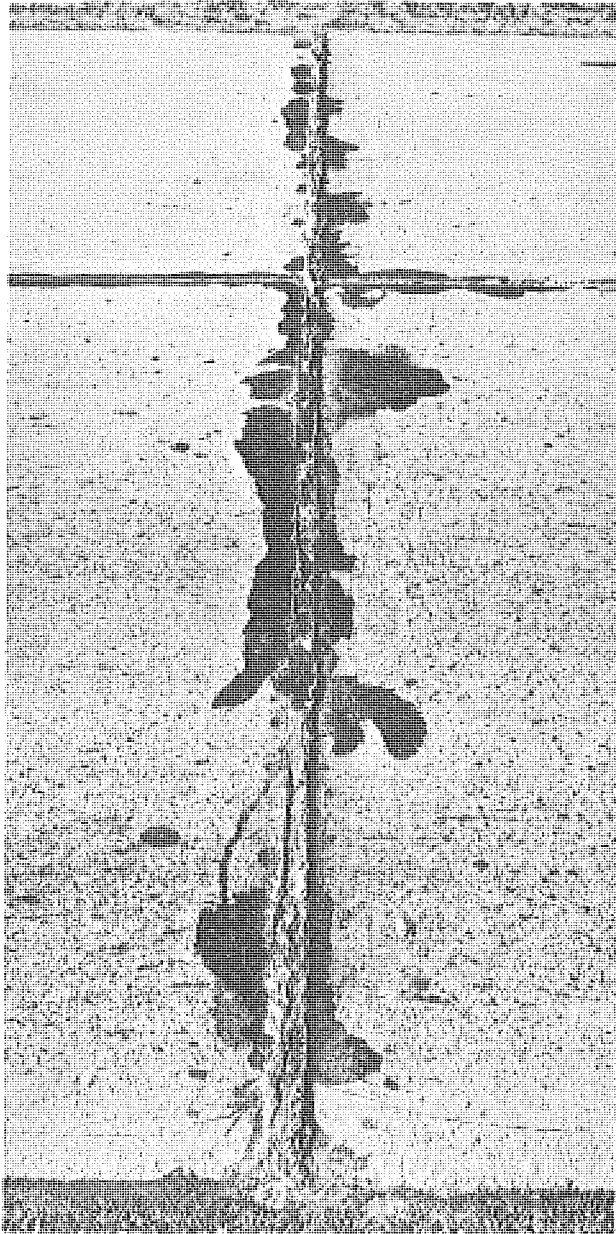
Section	Roughness data for US 127, in./mi.*	
	March 1961	May 1968
A	169	225
B	179	232
C	182	259
D	162	192
E	148	219

* On the basis of riding quality, Michigan has arbitrarily classified projects in three integrator-count categories:

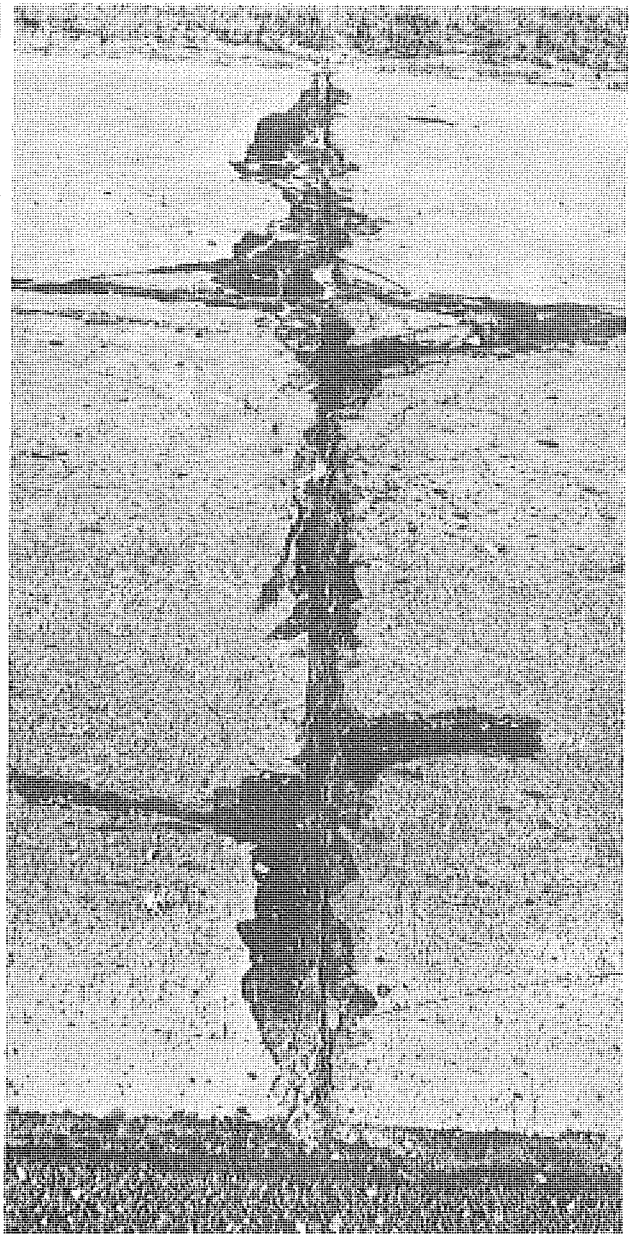
- "good" (0 to 130 accumulated inches per mile)
- "average" (131 to 174 accumulated inches per mile)
- "poor" (175 or more accumulated inches per mile)

SUMMARY

Roughness data taken in 1968 from both projects are compared with data taken in 1960 for Groesbeck Highway and in 1961 for US 127 in Table 2. The results indicate that roughness for Groesbeck Highway is higher than that for US 127. This probably resulted from concrete failure at the transverse joints and the deep patches required for them (Fig. 5). In addition,



Joint Disintegration on SB Roadway
near Fourteen Mile Road
Age: 16 years



Joint Disintegration on SB Roadway
near Doris Avenue.
Age: 16 years

Figure 5. Typical deterioration at transverse joints on
Groesbeck project (November 1968).

results of cracking surveys made in July 1970, show that average cracking was higher for Groesbeck Highway than that for US 127 (Table 3). At present, Groesbeck Highway needs resurfacing to provide a smooth ride.

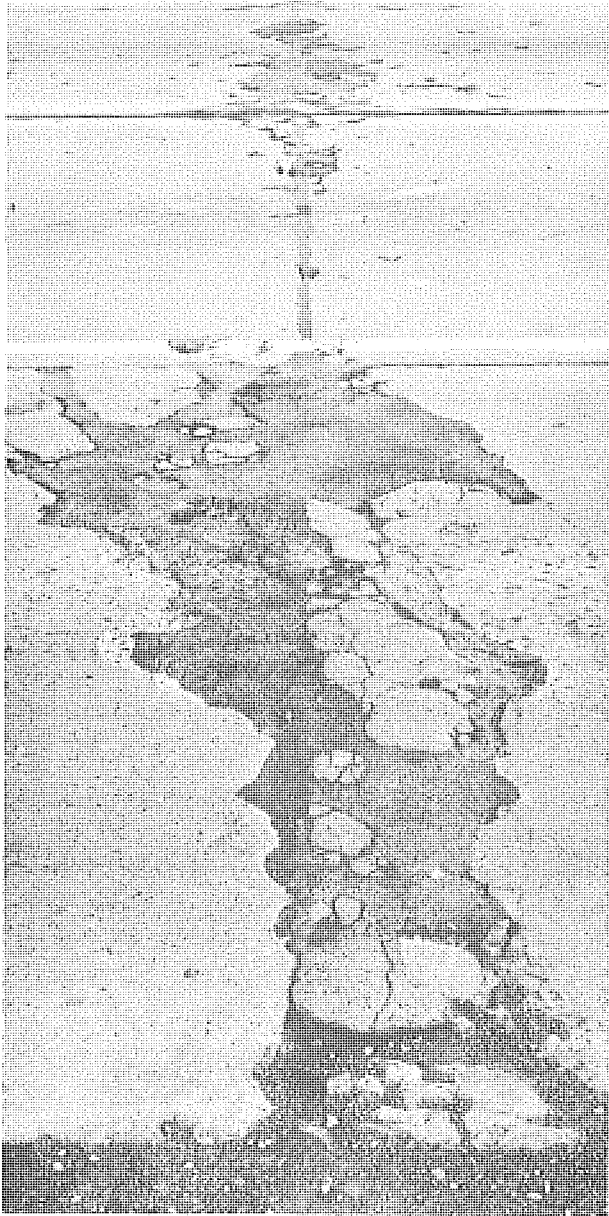
TABLE 3
SUMMARY OF AVERAGE CRACKING PER 100-FT STATION
FOR BOTH CONCRETE CAPPING PROJECTS
JULY 1970 SURVEY

Groesbeck Highway	Capping Method	Number of Cracks per 100-ft Station	
		NB	SB
	1	14.0	14.5
	2	15.5	14.6
	3	10.3	10.0
	4	9.1	9.6
US 127	Section	Number of Cracks per 100-ft Section	
		NB	SB
	A	Not included in experiment	5.8
	B		5.3
	C		6.3
	D		8.8
	E		4.6

Typical asphalt patches applied at transverse joints on US 127 are shown in Figure 6. In general, Table 2 shows that during the past eight years, pavement roughness for both projects changed from average ride to poor ride.

CONCLUSIONS

After 7 to 8 years service, the riding quality of both capped pavement projects was average approaching poor. After 15 to 16 years service neither capped pavement project provided a surface of acceptable riding quality. Therefore, the type of capping used appears to have a service life of no more than about 10 years.



Joint Disintegration
Station: 334+71
SB Roadway
Age: 15 years



Joint Disintegration
Station: 339+00
SB Roadway
Age: 15 years

Figure 6. Typical deterioration at transverse joints on US 127 project (November 1968).

Because of the large number of combined experimental factors, no conclusions can be drawn regarding the relative effectiveness of any of the various cap designs. If an evaluation of relative effectiveness is desired, additional tests must be conducted with either fewer variables or as a much larger scale experiment.

REFERENCES

1. "Concrete Resurfacing for Old Pavements," Portland Cement Association (1948).
2. "Experimental Concrete Capping on Groesbeck," Research Laboratory Report R-194, August 1953.
3. "Experimental Concrete Capping on Groesbeck Highway," Research Laboratory Report R-206, April 1954.
4. Lindy, O. L., "Experimental Concrete Capping on Groesbeck Highway," Research Laboratory Report R-331, May 1960.
5. Broughton, W., "Experimental Capping Study," Research Laboratory Report R-215, December 1954.
6. Lindy, O. L., "Experimental Concrete Capping," Research Laboratory Report R-353, April 1961.