RAPID SETTING CONCRETE PATCHING STUDY

FINAL REPORT

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Research Report No. 84

Research Project No. 71-1C(B)
Louisiana HPR 1 (12)

Conducted by
LOUISIANA DEPARTMENT OF HIGHWAYS
Research and Development Section
In Cooperation with
U. S. Department of Transportation
FEDERAL HIGHWAY ADMINISTRATION

March 1975

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Abstract

This investigation was prompted by the increasing number of concrete roadway failures which have required corrective action. A more permanent solution than the placing of hot or cold mixed asphalt compounds into concrete voids was deemed necessary. The research included as many generic types of concrete patching materials as was possible under the existing funding of the project. These concrete patching materials were examined in the laboratory to determine the basic physical properties, then roadway patches using the same materials were placed and subjected to a field performance evaluation under traffic loading.

Conclusions

It was found that Systems J, K, L and M were the most durable of the patching compounds evaluated. All others had bond failure, structural cracking or internal deterioration after one year exposure to field traffic.

Recommendation

It is recommended that a qualified products listing be established beginning with the acceptance of Systems J, K, L and M as approved patching materials and that new materials be added if they exhibit equal or better field performance properties after being exposed to traffic for a period of one year under conditions similar to the acceptable materials.

INTRODUCTION

This report describes the research effort directed at the determination of concrete patching methods and materials that will allow a highway to be repaired and reopened to traffic in a minimum amount of time.

The research was performed under project 71-1C(B), Rapid Setting Concrete Patching. The work was accomplished by the Concrete Research Unit of the Louisiana Department of Highways Research and Development Section as a part of a cooperative research program with the Federal Highway Administration.

This research resulted from the many problems that the maintenance forces had experienced during their highway concrete patching efforts. It was felt that what was needed were patching materials that could be placed and the roadway opened to traffic after six hours. This would allow an area to be repaired within an eight-hour shift.

PURPOSE

This study has as its primary purpose the determination of those parameters which are required to meet our desire to repair a roadway with a concrete patch and open the patched area to traffic in six hours. It is also desired that the patch installed will not scale, spall, crack or pop-out for a reasonable period of time.

SCOPE

Since there are literally hundreds of patching products presently available, the scope of this project was to select several generally different types of patching products to investigate and attempt to arrive at a common acceptance specification through the establishment of performance parameters. Once the parameters for acceptance are known, any material not included in this study could qualify for usage by the maintenance forces should it be found to possess the requirements deemed necessary to produce a good patch.

METHOD OF PROCEDURE

It was deemed necessary at the onset of this study to substantiate and/or correlate the results of laboratory testing with a field test. The laboratory testing would include the testing and analysis of specimens made from the various patching systems, while the field testing would be the evaluation of physical behavior of the patching systems installed on a highway and subjected to normal traffic volume. The method of procedure which follows is therefore divided into Laboratory Testing and Field Testing.

Laboratory Testing

This phase of work began with receiving and recording the requisitioned patching materials. Since the State of Louisiana does not endorse any proprietary product and the researchers are concerned only with the establishment of performance parameters for the eventual development of acceptance testing requirements, the identities of the various brand names have been coded, since it is not the intent to judge individual performances. The following alphabetical designation for the systems described will be used throughout this report.

- System A - premixed patching compound
- System B - premixed patching compound
- System C - premixed patching compound
- System D - a special cement that was used with native aggregate
- System E - the same special cement as in System D, but utilized a different mix design
- System F - liquid accelerator that was added to the mixing water of a concrete mix
- System G - the same accelerator as in System F, but utilized a different ratio of accelerator to mixing water
- System H - a mixture of ASTM Type III cement and aggregate
- System I - the same cement as System H, but utilized a different cement factor

The laboratory analysis began by analyzing the information supplied with each system, such as the mixing and handling instructions. Preparation for initial mixing began after the information gathering process was completed. The initial mixing required that a small amount of each system be hand mixed for the determination of the approximate working time and the water requirements. During the initial mixing several systems proved to have an extremely rapid set time, and it was decided that those materials should not be machine mixed in the electric mixer for fear that the material may set up in the drum. Those materials were hand mixed with shovels in a large metal pan.

The following were the mix designs for the systems tested:

System A

Type of Cement	Premixed Grout	90 pounds
Cement Factor	---	---
Fine Aggregate	---	---
Coarse Aggregate	---	---
Water	13 percent by volume	11.7 pounds
Slump	2-1/4 inch	---
Fresh Weight	160 pounds per cubic foot	

System B

Type of Cement	Premixed Grout	100 pounds
Cement Factor	---	---
Fine Aggregate	---	---
Coarse Aggregate	---	---
Water	---	13.5 pounds
Slump	3-3/4 inch	---
Fresh Weight	162.8 pounds per cubic foot	

System C

Type of Cement	Premixed Grout	120 pounds
Cement Factor	---	---
Fine Aggregate	---	---
Coarse Aggregate	---	---
Water	---	23 pounds
Slump	3 inches	---
Fresh Weight	Not enough time to check	

System D

Type of Cement	Special	100 pounds
Cement Factor	6	---
Fine Aggregate	Concrete Sand	216 pounds
Coarse Aggregate	Concrete Gravel	316 pounds
Water	5 gallons	41.5 pounds
Slump	2-1/4 inches	---
Fresh Weight	146.4 pounds per cubic foot	

System E

Type of Cement	Special	100 pounds
Cement Factor	7	---
Fine Aggregate	Concrete Sand	183 pounds
Coarse Aggregate	Concrete Gravel	268 pounds
Water	4 gallons	33.5 pounds
Slump	2-1/2 inches	---
Fresh Weight	146.4 pounds per cubic foot	

System F

Type of Cement	ASTM Type I	94 pounds
Cement Factor	6	---
Fine Aggregate	Concrete Sand	207 pounds
Coarse Aggregate	Concrete Gravel	313 pounds
Water	5.5 gallons	46 pounds
*Accelerator to Water Ratio	1:5	---
Slump	2-1/2 inches	---
Fresh Weight	145.6 pounds per cubic foot	

System G

Type/Weight of Cement	ASTM Type I	94 pounds
Cement Factor	6	---
Fine Aggregate	Concrete Sand	204 pounds
Coarse Aggregate	Concrete Gravel	308 pounds
Water	5.8 gallons	49 pounds
*Accelerator to Water Ratio	1:3	---
Slump	2 inches	---
Fresh Weight	145.2 pounds per cubic foot	

System H

Type/Weight of Cement	Type III	94 pounds
Cement Factor	7	---
Fine Aggregate	Concrete Sand	161 pounds
Coarse Aggregate	Concrete Gravel	266 pounds
Water	5 gallons	41.5 pounds
Slump	3 inches	---
Fresh Weight	146.8 pounds per cubic foot	

System I

Type/Weight of Cement	Type III	94 pounds
Cement Factor	8	---
Fine Aggregate	Concrete Sand	137 pounds
Coarse Aggregate	Concrete Gravel	227 pounds
Water	4.38 gallons	36.5 pounds
Slump	3-1/4 inches	---
Fresh Weight	146.4 pounds per cubic foot	

* This system was a normal concrete mixture which used a low shrinkage liquid accelerator that was added to the mixing water. The water-accelerator ratio may be varied, dependending upon the speeds of set and high early strength desired.

Specimens were prepared from each of the preceding systems and subjected to the following tests:

AASHO T-126	Compressive Strength Using 6-Inch by 12-Inch Cylinders
AASHO T-126	Flexural Strengths Using 6-Inch by 6-Inch by 12-Inch Beams
AASHO T-126	Compressive Strengths Using 2-Inch Cubes
ASTM C-666	Resistance of Concrete to Rapid Freezing and Thawing
ASTM C-138	Unit Weight, Yield and Air Content

Also, an effort was made to examine not only the material itself but the physical properties between the patching material and that of normal hardened concrete. Special beam forms were made and half filled with normal concrete. The texture of the normal concrete was slightly roughened, then the half beam was allowed to cure in its mold. After 28 days of curing the top half of the beam was poured with the patching material and it was allowed to cure for 28 days. These beams were then subjected to freeze and thaw analysis in an effort to determine what effects the freezing and thawing would have on the bonding properties of each patching material. It was theorized that any significant drop in the modulus frequency, which is performed as a part of the freeze and thaw analysis, would indicate a subsequent loss of bond between the patching material and the concrete half beam onto which it was placed. This test procedure was called the "Split Beam Durability Test."

The results of this testing program are tabulated in the Discussion of Results-Laboratory Work Section of this report.

Field Testing

Louisiana Route 37, Greenwell Springs Road, leading northeasterly out of the Baton Rouge area, was selected to be the site of the field installation because it appeared to carry a normal amount of traffic.

The procedure used required that traffic control be maintained and proper signing be employed. The work began each morning with location of areas to be patched and the deployment of proper traffic controls. The areas to be patched were then marked off, and a jack hammer was used to remove the faulted concrete. After the chipping operation, the area was cleaned by blowing with the air hose attached to the compressor. The materials used in the patching systems were then weighed, proportioned and placed in a gasoline powered three and one-half cubic foot mixer. The systems were then placed in the prepared area, finished off and cured. Approximately six hours after placement, the traffic controls were removed; and the traffic was allowed to pass over the patches.

The patching systems were applied in May, 1972, and inspected quarterly for a period of one year. The quarterly evaluations consisted of a visual inspection and undersurface failure detection. The visual inspection was concerned with cracking, scaling, and spalling of the patch. This was recorded by photo-documentation. Undersurface failure (delamination) detection was accomplished by using a chain drag and listening for acoustical differences.

Systems A, B, C, E, G and I were applied in the field. Systems D, F and H were not applied in the field. This is due to the fact that D, F and H are sister systems of E, G and I, respectively, with only the mix design changing in each. The apparent quicker setting and stronger mix of the sister systems were used in the field testing program.

DISCUSSION OF RESULTS

Analysis of Laboratory Data

Listed in Tables 1a and 1b are the results of the test performed on the specimens made from the different patching systems. General remarks concerning the results of testing are as follows:

System A: The early compressive strength was considered good, as it obtained a psi of over 3000 within six hours. The flexural strength at six hours was 386 psi, which also was considered to be more than adequate. The freeze and thaw analysis was also very good.

The bond to hardened concrete of System A was questionable. The special split beam, when air dried, developed a slight crack between the two layers.

System B: The early compressive and flexural strengths were good. The dry shrinkage tests results were higher than that of normal concrete. The durability of the material when subjected to freeze and thaw analysis was good with only light surface scaling. The bond of the material to hardened concrete is questionable, since a slight crack occurred in the bond area of the split beam when air dired.

System C: This material had a very rapid set time, however, the six-hour strengths were considered low. The durability of the material itself is better than normal concrete; however, again as in Systems A and B, the bond to hardened concrete is questionable. During a period of drying out in air, a crack developed in the bond area of the split beam; and the split beam had an early failure of durability under freeze and thaw analysis.

System D: This material had a low six-hour compressive and flexural strength. The durability of this system and its sister, System E, was the lowest of all systems tested. No split beams were tested for this system.

TABLE 1a

RESULTS OF LABORATORY TESTING - PHASE I

System	Autoclave Expansion (%)	Average Dry Shrinkage at 60 Weeks (in./in.)	Durability Factor	Durability Factor of the Split Beam	Initial Set Time	Final Set Time
A	+.03	.144	100.00	4.7	0 hr. 51 min.	1 hr. 20 min.
B	+.03	.160	100.00	5.1	1 hr. 20 min.	1 hr. 54 min.
C	+.01	.146	98.30	2.5	0 hr. 6 min.	0 hr. 11 min.
D	+.12	.043	00.96	NSM*	0 hr. 28 min.	0 hr. 30 min.
E	+.12	.044	00.91	1.5	0 hr. 27 min.	0 hr. 31 min.
F	+.10	.049	6.20	2.3	1 hr. 42 min.	2 hrs. 27 min.
G	+.10	.048	2.80	NSM*	1 hr. 40 min.	2 hrs. 10 min.
H	+.23	.043	8.60	NSM*	3 hrs. 15 min.	4 hrs. 30 min.
I	+.23	.039	9.60	NSM*	3 hrs. 10 min.	4 hrs. 28 min.

* NSM - No Specimens Made

TABLE 1b

RESULTS OF LABORATORY TESTING - PHASE I

System	Compressive Strengths (PSI)				Flexural Strengths (PSI)					Cube Strength (PSI)		
	6 hours	24 hours	7 days	28 days	6 hours	24 hours	7 days	28 days	6 hours	24 hours	7 days	28 days
A	3113	5509	8685	10735	386	606	1090	1368	2079	5333	10583	12619
B	2632	5229	7792	9645	450	679	1396	1481	1298	4604	5663	7000
C	543	1562	3551	3914	116	242	852	888	696	710	3385	4997
D	560	2093	2661	3180	102	364	374	429	450	1978	3256	4079
E	565	2148	2770	3409	130	419	496	468	559	2411	4404	4850
F	744	2049	4052	5342	149	353	568	707	524	2472	6492	8542
G	976	2668	4879	6134	211	441	564	743	844	2900	6255	8492
I	174	2229	4494	5476	---	515	666	810	113	3196	8750	10892
J	358	2692	4846	5618	---	412	667	844	229	4290	9792	11717

*NSM - No Specimens Made

System E: This patch used the same material as System D, except the cement factor was seven, whereas System D had a cement factor of six. The six-hour compressive and flexural strengths were considered low. A split beam durability test was performed for this system, and the results indicated that the bond to hardened concrete was not successful. The material itself had a very low durability factor.

System F: The accelerating additive was mixed with the water used in the system at a ratio of 1:5. The resulting six-hour compressive and flexural strengths were considered low. The dry shrinkage was comparable to that of regular concrete. The durability factor was lower than normal concrete. Since the split beam durability factor was lower than that for the material itself, the failure probably occurred in the bond area.

System G: This system is essentially the same as System F, except that a ratio of 1 to 3 was used for the accelerating additive. The 1:3 ratio increased the six-hour compressive and flexural strength by approximately 50 percent. The durability factor for this 1:3 ratio System G was lower than the 1:5 ratio System F. The split beam test was not performed.

System H: Systems H and I were used as control systems, since many maintenance units use seven-and eight-bag mixes of High Early Cement to perform patching, except that their patches are not usually loaded before curing for 24 hours. System H had a very low compressive strength at six-hours (174 psi). No flexure tests were performed at six-hours, but it may be assumed that they would be very low. The durability was only slightly less than the eight-bag System I. The split beam test was not performed.

System I: With the addition of one bag of cement over System H, System I's six-hour compressive strength was more durable than that of System H, but was still considered very low. The split beam test was not performed.

Analysis of Field Evaluation

The patches were inspected at the time of installation and at intervals of three months for one year. If more than one patch of a system was installed it was designated by a number following the alphabetical system designation i.e., A-1, A-2, B-1, C-1, C-2, C-3, etc. The following figures provide the field analysis of each system.

SYSTEM A-1

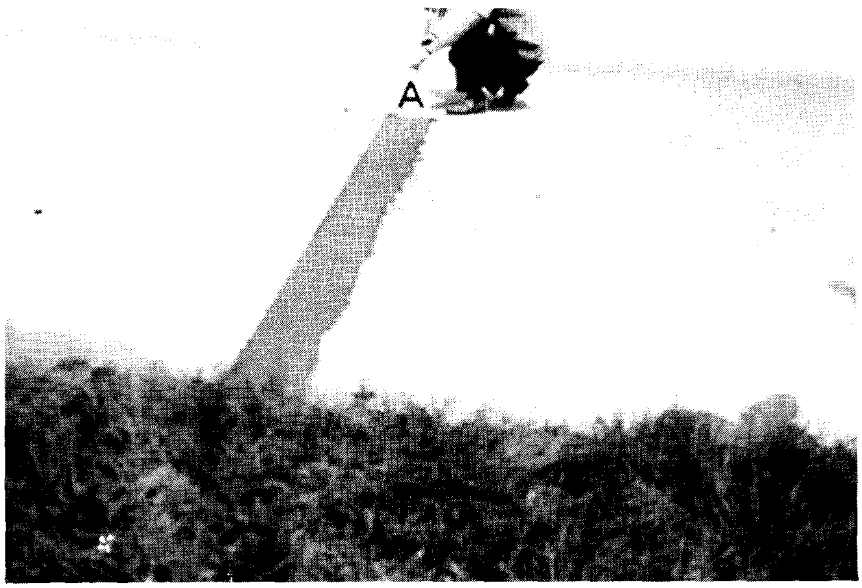


FIGURE 1
IMMEDIATELY AFTER PLACEMENT

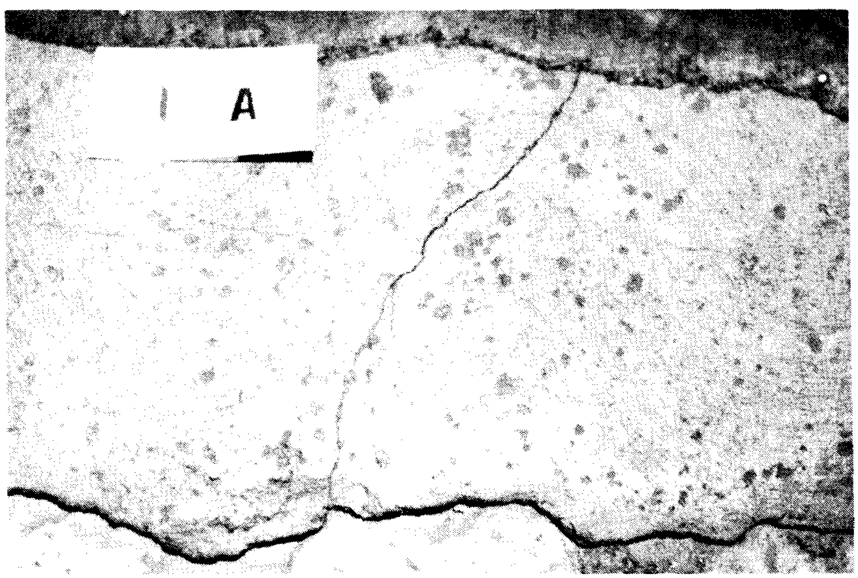


FIGURE 2
AFTER ONE YEAR

After one year the crack at the bond ran the total length of the patch with the spalling between the patch and surrounding pavement increasing. There were six longitudinal and one transverse crack present in the patch.

SYSTEM A-2

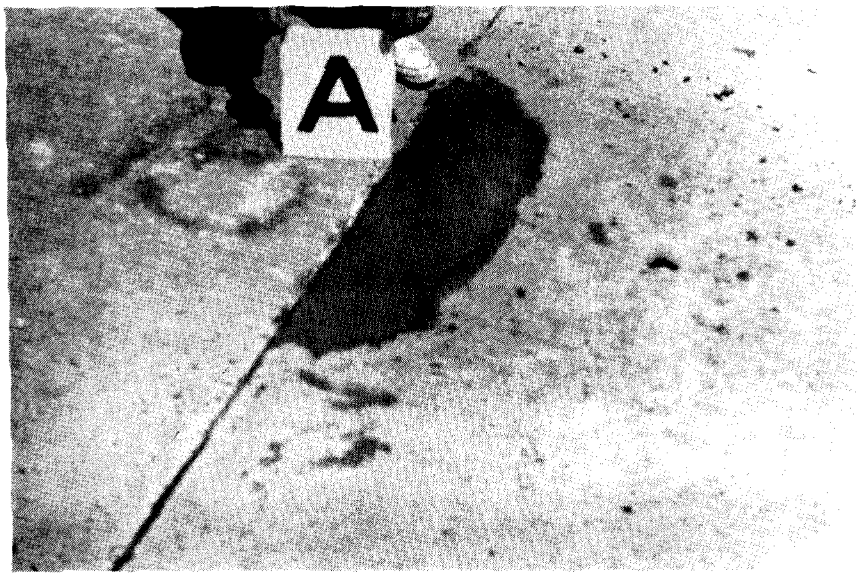


FIGURE 3
IMMEDIATELY AFTER PLACEMENT

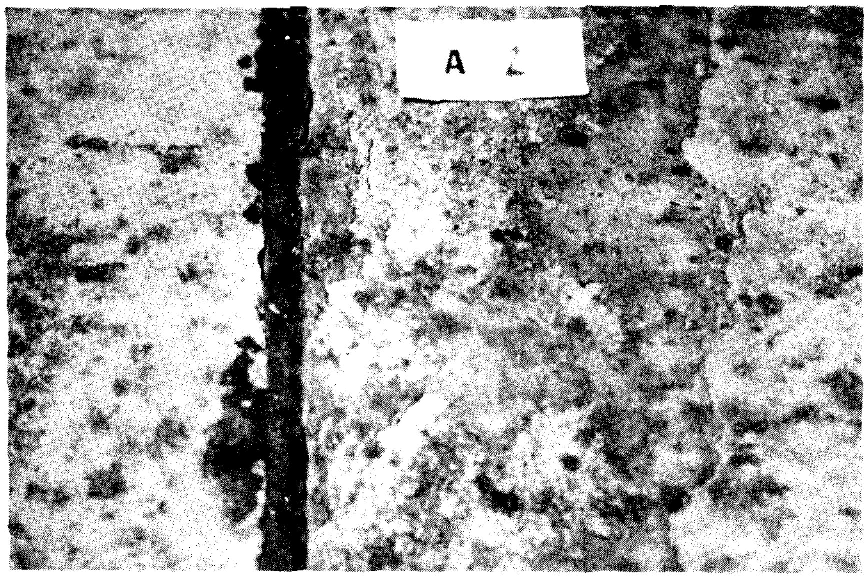


FIGURE 4
AFTER ONE YEAR

The one-year inspection revealed that approximately 80 percent of the patch area had spalled, but the bond remained good.

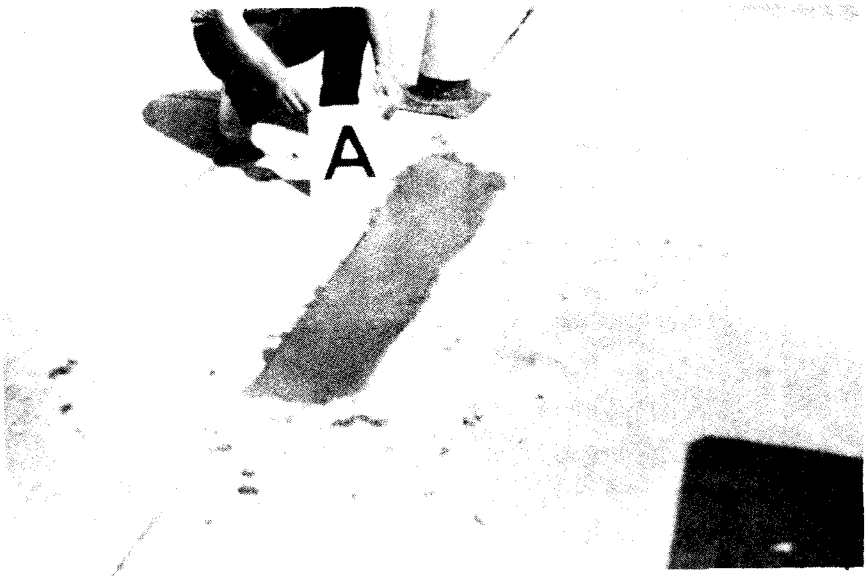


FIGURE 5
IMMEDIATELY AFTER PLACEMENT

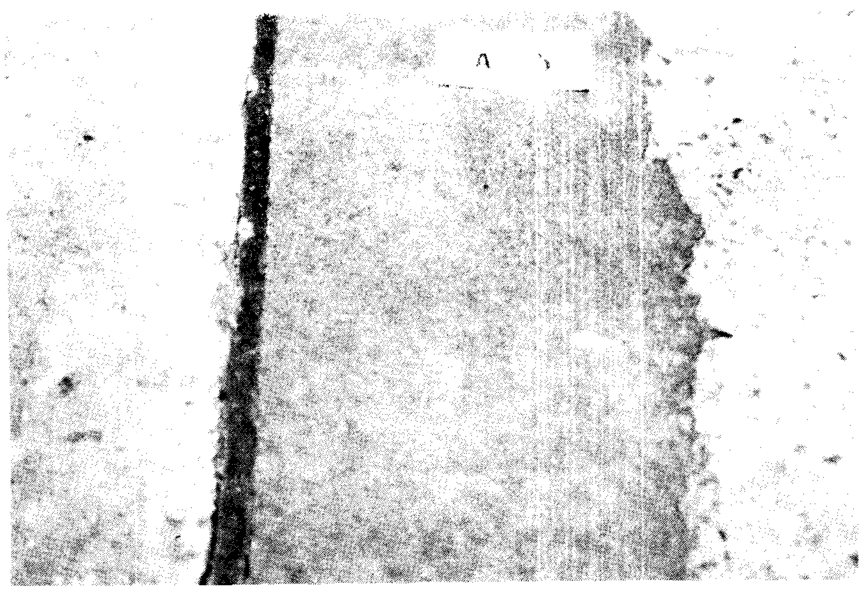
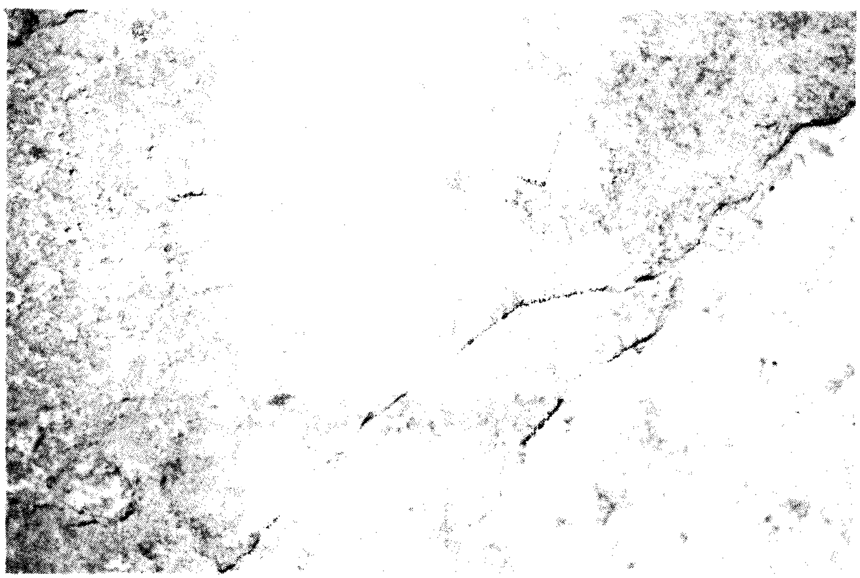


FIGURE 6
AFTER ONE YEAR

Very light spalling was beginning to occur after one year of traffic. The bond to the old concrete remains good.

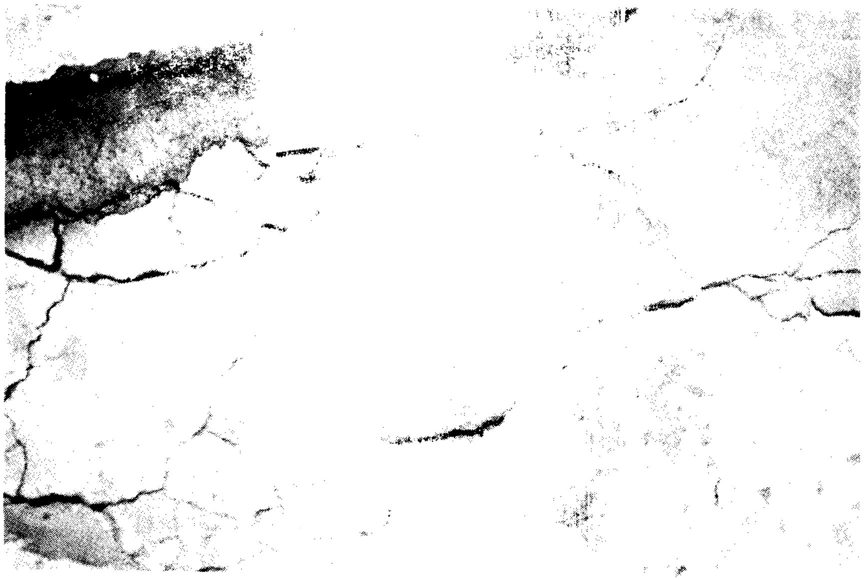


After one year a crack in the bond area had developed and the spalling was becoming heavy.

FIGURE 9
IMMEDIATELY AFTER PLACEMENT

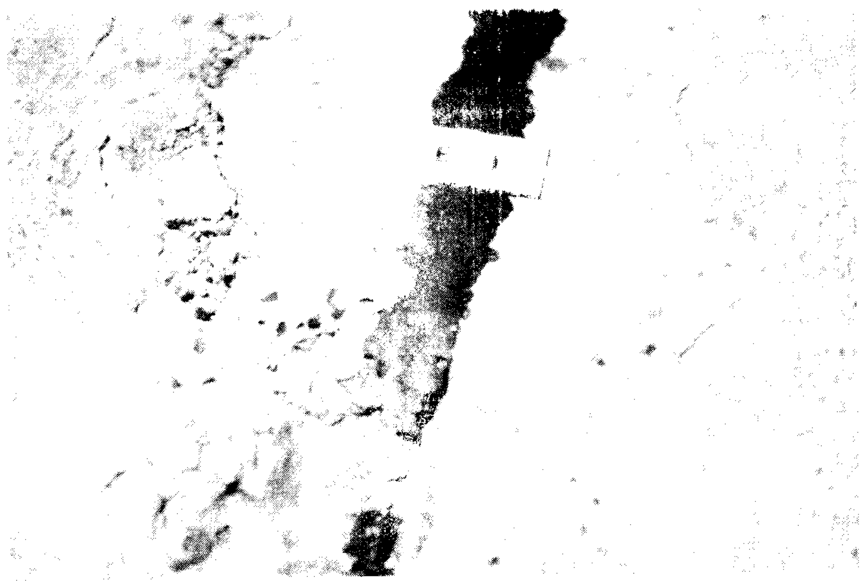
FIGURE 10
AFTER THREE MONTHS OF TRAFFIC

It was found during the three months inspection that the patch had apparently failed and popped-out and was replaced by the maintenance forces with hot mix sometime during the first three months. No further record was kept on this patch.



After one year of service [illegible] and spalling had occurred.

[illegible]



[illegible]

After one year of service the patch was beginning to deteriorate rapidly. The bond area was beginning to spall and open and aggregates were being exposed due to traffic wear.

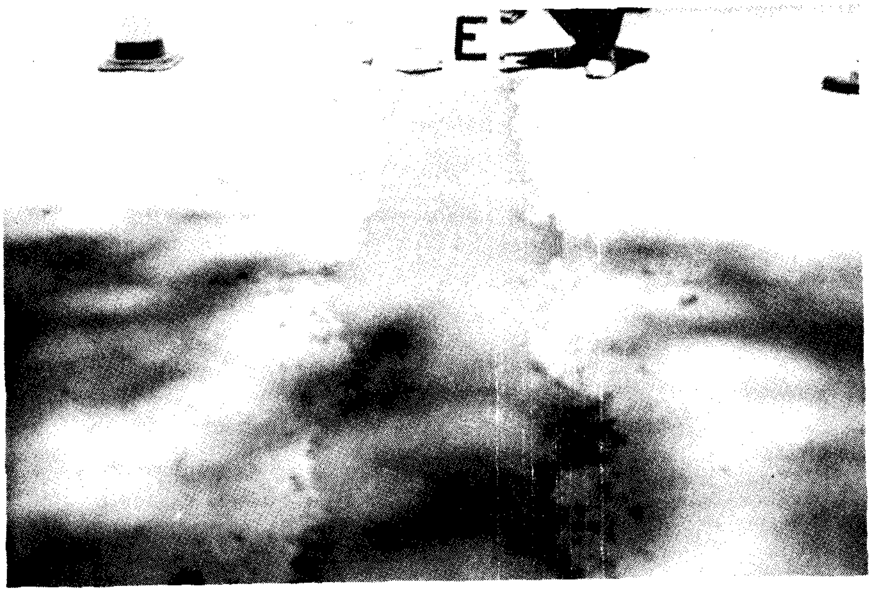


FIGURE 15
IMMEDIATELY AFTER PLACEMENT

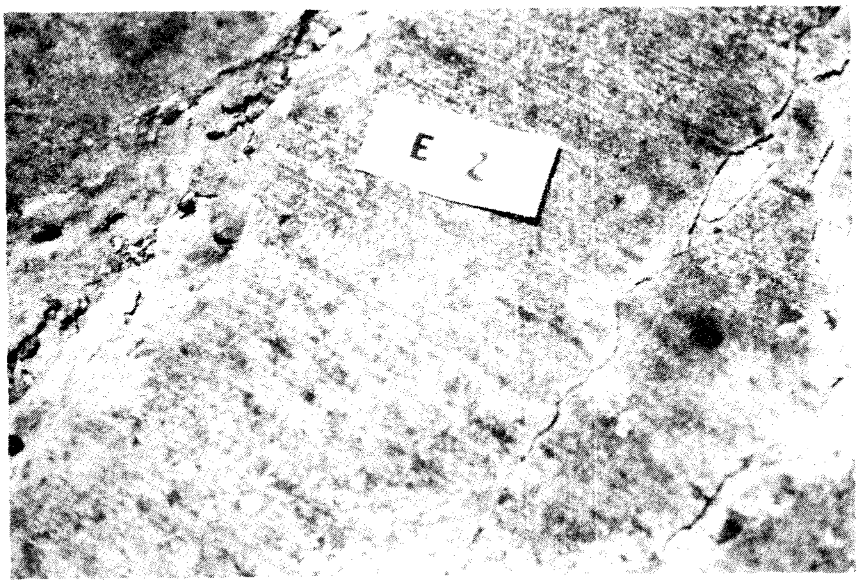


FIGURE 16
AFTER ONE YEAR

After one year of service there was much spalling at the crack along the bond area.

SYSTEM G-1

FIGURE 19
IMMEDIATELY AFTER PLACEMENT

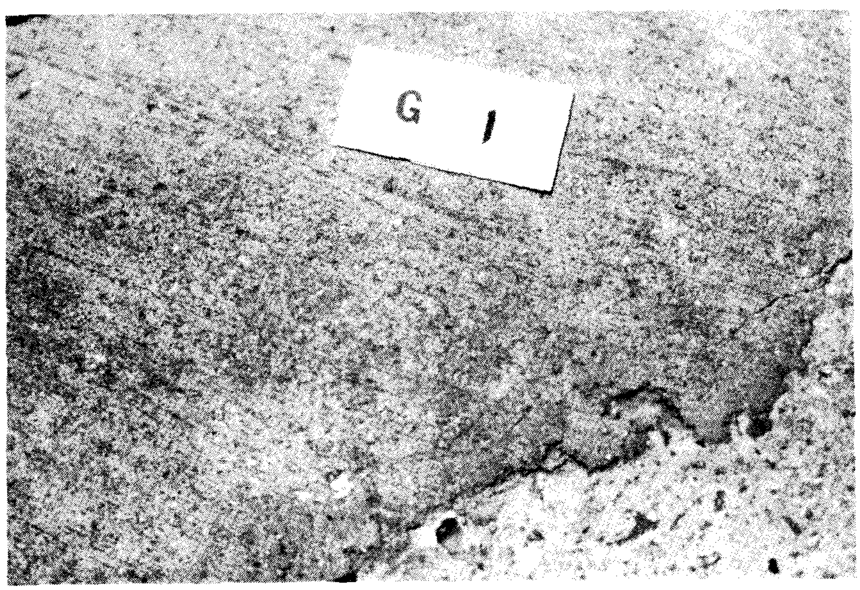


FIGURE 20
AFTER ONE YEAR

After one year of service the patch had four hairline longitudinal cracks, some surface wear, very little spalling and a relatively good bond to the surrounding concrete.

SYSTEM G-2

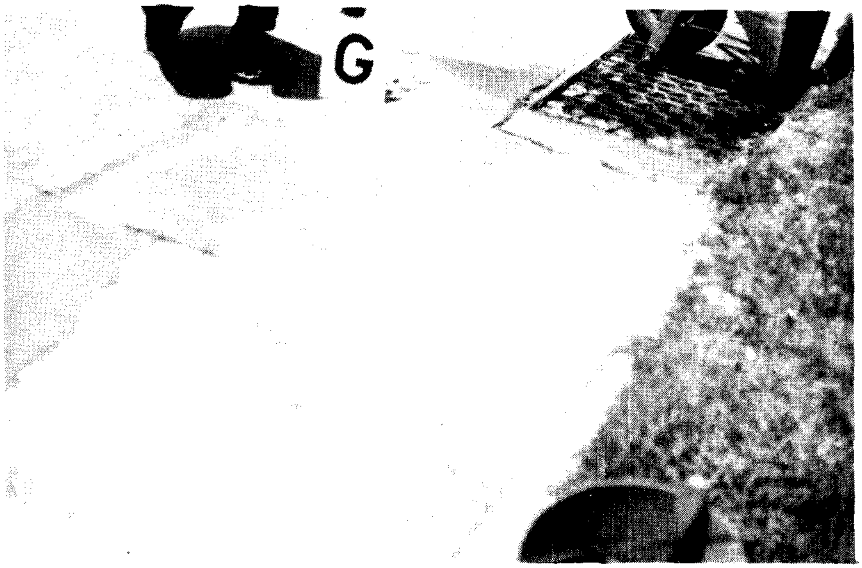


FIGURE 21
IMMEDIATELY AFTER PLACEMENT

FIGURE 22
AFTER ONE YEAR

After one year of service the spalling at the bond area on one side had occurred. The patch had only light surface wear.

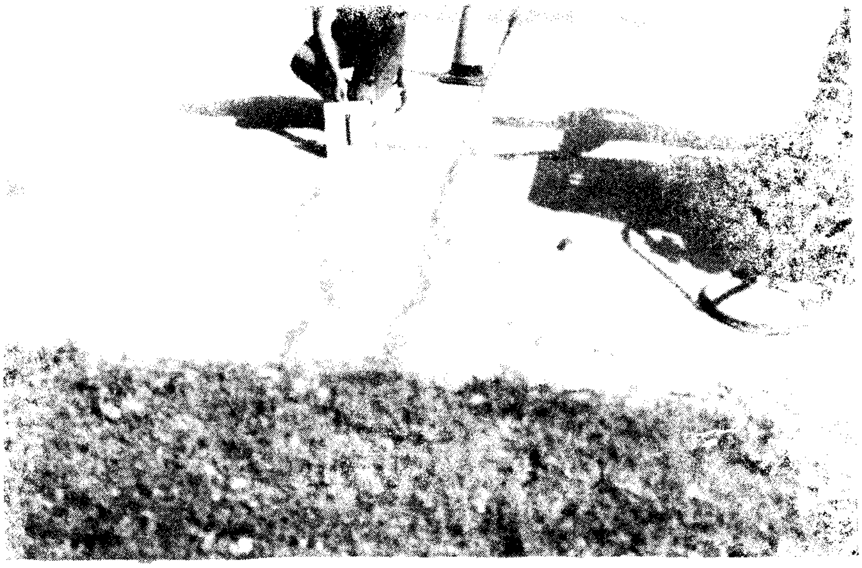
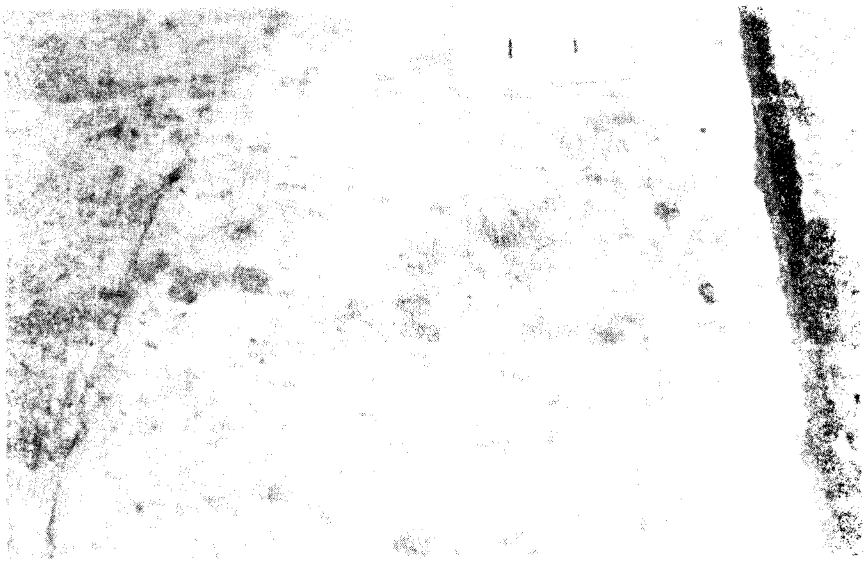


FIGURE 13
IMMEDIATELY AFTER PLACEMENT



[illegible]
[illegible]

After one year of service the patch had one longitudinal crack and a crack between the patch and surrounding concrete. The general condition appeared good.

ADDITIONAL TESTING

It was discovered during the field evaluation that the rapid patching materials being accepted under the existing specifications were not withstanding the traffic loading, as had been anticipated; and there was no apparent correlation between the initial laboratory compressive strength and roadway durability. At this point in the study a recommendation was made that addtional patches be placed in an effort to find acceptable materials that would meet our anticipated performance parameters.

Since a greater amount of maintenance time is expended patching bridge decks, it was decided that any additional patching should be oriented to bridge deck repair. Also, additional testing should be performed in the extreme northern section of the state in an effort to determine the effect freezing temperatures and winter application of deicing salts may have on patching materials.

With these requirements established, the additional testing phase was launched. The laboratory testing procedures and the field evaluation reviews remained the same as had been previously performed during the earlier phase of this project. The Bayou Bartholomew Bridge on Louisiana Route 139 and the Bayou Lafourche Bridge on U. S. Route 80 were selected for field installations. Both were in the extreme northeastern section of the state.

Five rapid patching materials were selected for this testing and evaluation program.

Laboratory Testing

As were performed during the early phase of the study, data was obtained in the laboratory prior to field installation in order to determine set time, strengths, and durability. The following are descriptions and mix designs of the materials used during this phase of the study.

System J: A calcium aluminate cementious material that was mixed on site in the following proportions:

Cement	94 pounds
Fine Aggregate	164 pounds
Coarse Aggregate (C-3)	204 pounds
Water	34.5 pounds (4.125 gallons)
Slump	4 inches to 5 inches
Fresh Weight	147.6 pounds

System K: A regulated set cementious material mixed in the following proportions:

Cement	100 pounds
Fine Aggregate	161 pounds
Coarse Aggregate (C-3)	192 pounds
Water	41.73 pounds (5 gallons)
Slump	4 inches to 6 inches
Fresh Weight	142.8 pounds

14 ounches of citric acid added per sack of cement.

System L: A cementious material containing gypsum that was blended with fine aggregate as follows:

Cement	100 pounds
Fine Aggregate	100 pounds
Water	23 pounds (2.76 gallons)
Slump	material flows

System M: A premixed packaged material that was mixed as follows:

Premixed	100 pounds
Water	11pounds
Slump	4 inches
Fresh Weight	144.8 pounds

System N: A premixed packaged material which utilized a complex phosphoric additive in lieu of water for mixing in the following proportions:

Premixed	100 pounds
Special Liquid	22.5 pounds

The results of the laboratory testing are found in the following tables.

TABLE 2a
RESULTS OF LABORATORY TESTING - PHASE II

System	Autoclave Expansion (%)	Average Dry Shrinage at 16 Weeks (in./in.)	Durability Factor	Durability Factor of the Split Beam	Initial Set Time	Final Set Time
J	-0.01	.028	34.0	28.2	3 hrs. 50 min.	4 hrs. 23 min.
K	*	.064	21.7	6.1	8 min. to 12 min.	10 min. to 14 min.
L	+0.02	.041	94.2	16.1	13 min. to 17 min.	15 min. to 25 min.
M	+3.50	.089	82.0	25.8	50 min. to 70 min.	2 hrs. ± 20 min.
N	*	.018	76.6	23.9	4 min. to 8 min.	8 min. to 12 min.

* Broken During Test

TABLE 2b

RESULTS OF LABORATORY TESTING - PHASE II

System	Compressive Strengths Initial	24 hours	7 days	28 days	Flexural Initial	24 hours	7 days	28 days	Cubes Initial	24 hours	7 days	28 days
J	2166 6 hrs.	5575	6207	6231	155 6 hrs.	675	965	976	1068 6 hrs.	11517	13735	14692
K	2380 3 hrs.	3107	4832	5128	350 3 hrs.	378	869	883	2067 3 hrs.	3540	7704	8592
	2633 6 hrs.				352 6 hrs.				2919 6 hrs.			
L	2281 1 hr.	4015	4545	5901	358 6 hrs.	535	633	793	2885 1 hr.	4563	5307	5925
	2686 6 hrs.								2936 6 hrs.			
M	890 6 hrs.	3432	5315	6405	---	444	856	899	778 6 hrs.	4796	8263	9175
	1539 7 hrs.								1050 7 hrs.			
N	2222 1 hr.	3330	4364	6157	517 6 hrs.	575	633	753	643 1 hr.	3163	5284	5825
	2730 3 hrs.								1231 3 hrs.			
	3044 6 hrs.								1795 6 hrs.			

Analysis of Data

General remarks concerning the test results are as follows:

System J: The compressive strength at six hours was considered adequate in view of the very high 24-hour compressive strengths. The flexural strengths followed the same pattern as the compressive strength. The durability factor of 34.0 ranked fourth of the five added materials which ranged from a low of 21.7 to a high of 94.2. However, the split beam durability factor of 28.2 for this material ranked first of the five, which ranged from 6.1 to 28.2. This would tend to indicate good bonding characteristics of the material to old concrete.

System K: The six-hour compressive and flexural strengths were considered adequate, but the material had the lowest durability factors of the materials tested. The failure of the bond in the split beam durability test was credited for the low factor in that test.

System L: The six-hour compressive and flexural strengths were considered adequate. This material had the highest durability factor, but due to a failure of the bond the material ranked fourth in the split beam durability test. It should be stated that the material, although ranking fourth, was very close to the top three in the split beam test.

System M: This material did not have very high compressive and flexural strengths at six hours but had very good durability, ranking second in both the standard durability and split beam tests. The material bonded to the old concrete very well.

System N: This material had a very rapid set and high early strengths. The laboratory durability factor and split beam durability factor were considered good. This material must not come into contact with water during handling or setting. The water will destroy the strength of the material.

Field Evaluation

Using the five additional materials twenty-two patches were placed on the two bridges in the numbers as follows:

	Bayou Bartholomew	Bayou Lafourche
System J	2	3
System K	2	3
System L	3	2
System M	2	3
System N	1	1
Totals	10	12

The following photographs are a record of the field tests.

FIGURE 25
IMMEDIATELY AFTER PLACEMENT

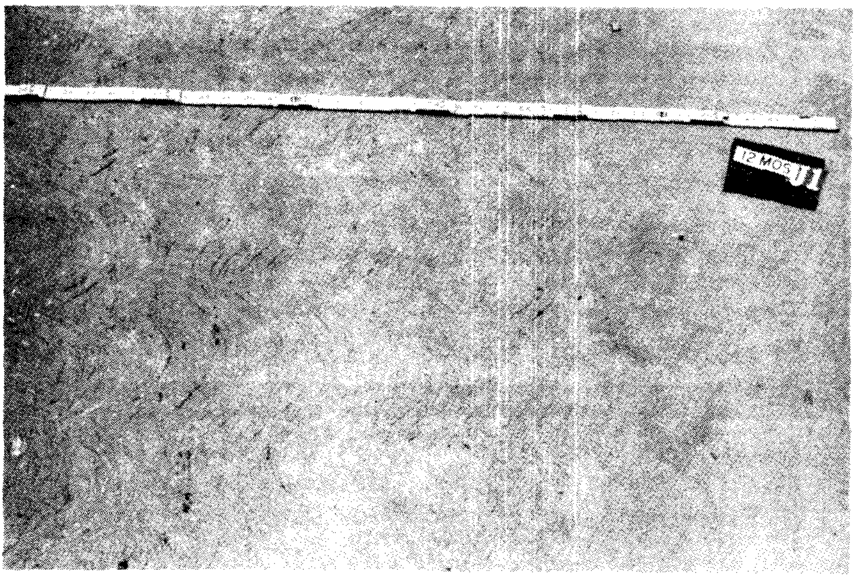
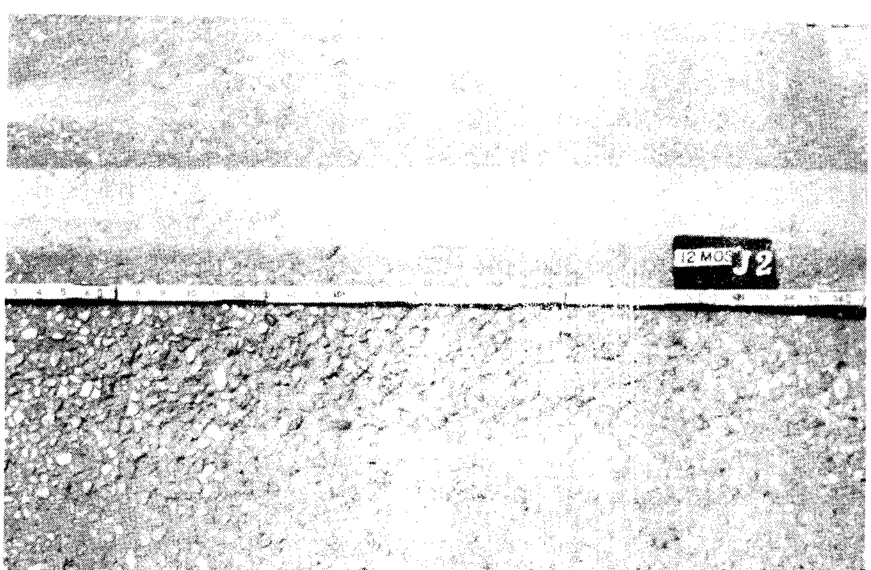


FIGURE 26
AFTER ONE YEAR OF TRAFFIC


12 MOS
J2

PATCH J-3

FIGURE 29
IMMEDIATELY AFTER PLACEMENT

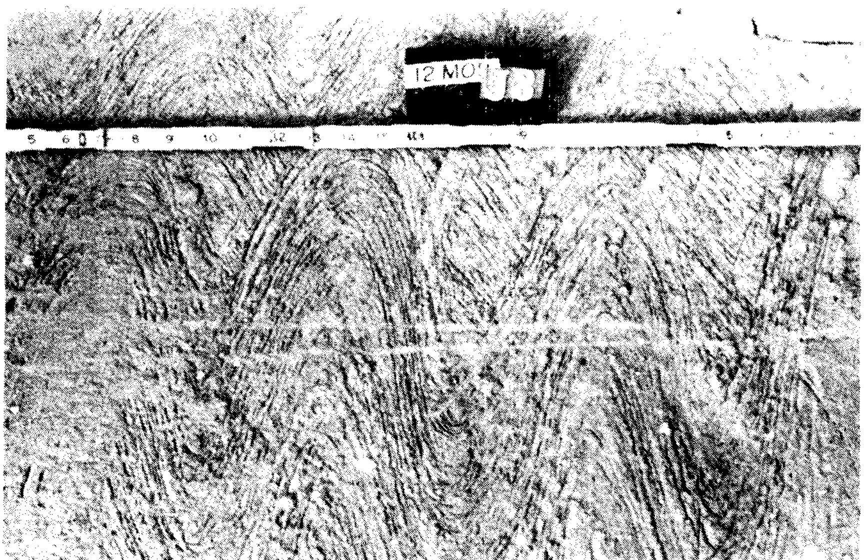


FIGURE 30
AFTER ONE YEAR OF TRAFFIC

PATCH J-4

FIGURE 31
IMMEDIATELY AFTER PLACEMENT

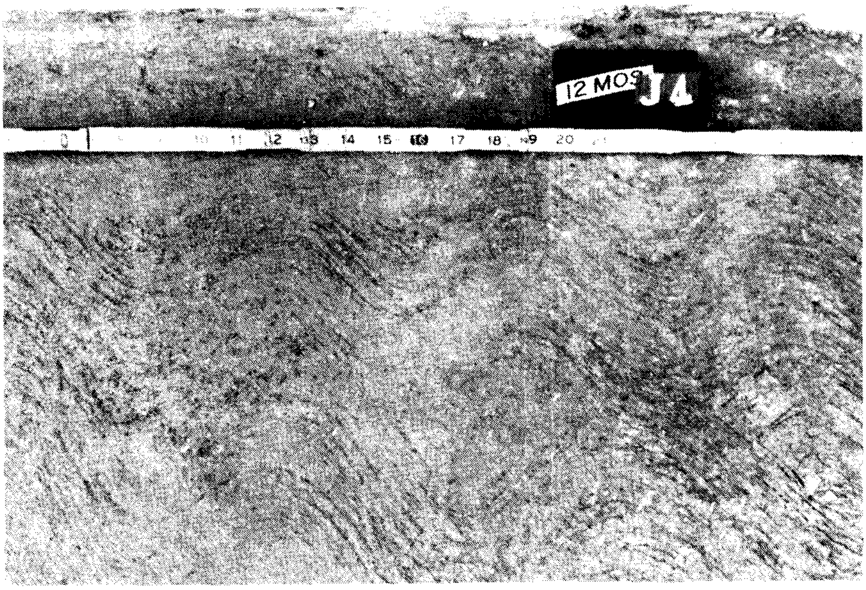
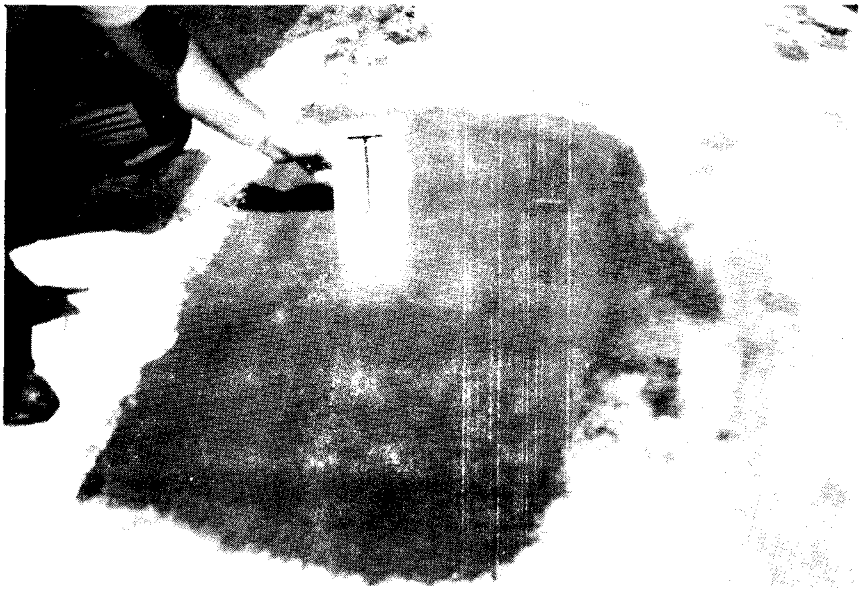
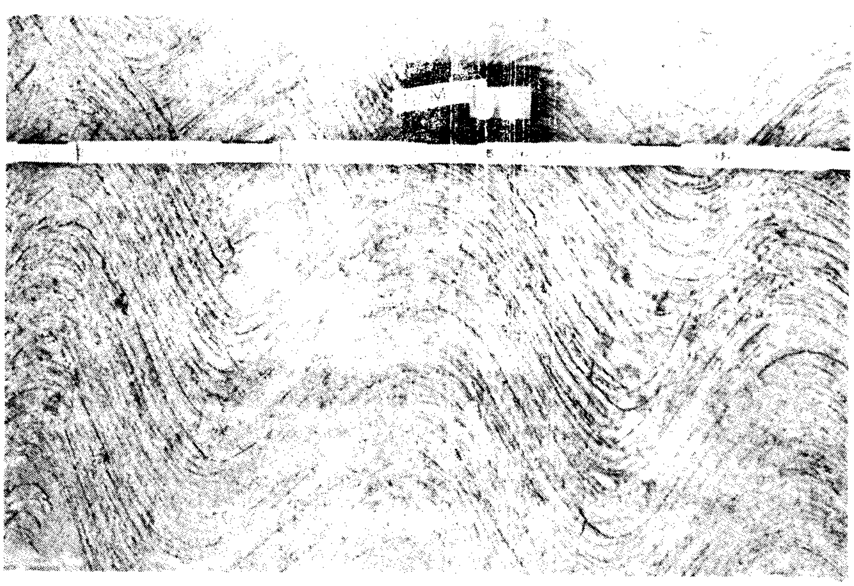


FIGURE 32
AFTER ONE YEAR OF TRAFFIC

PATCH J-5



[illegible] …CEMENT



[illegible] TRAFFIC

PATCH K-1

FIGURE 35
IMMEDIATELY AFTER PLACEMENT

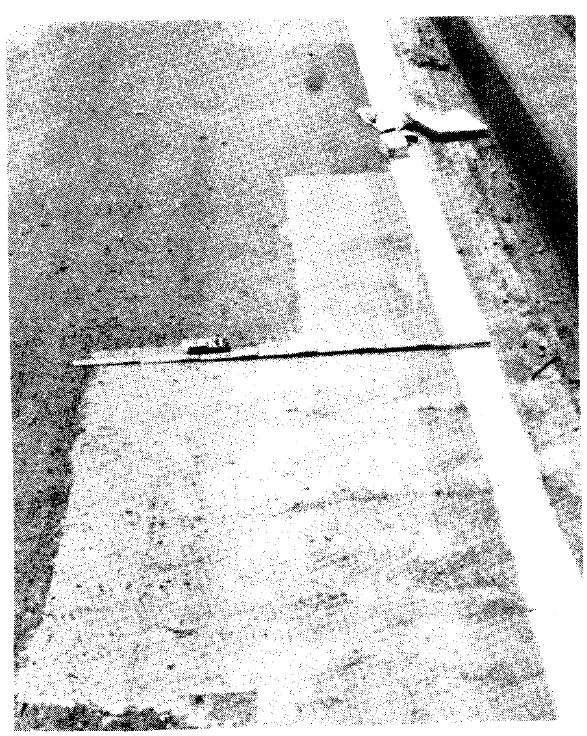


FIGURE 36
AFTER ONE YEAR OF TRAFFIC

PATCH K-2

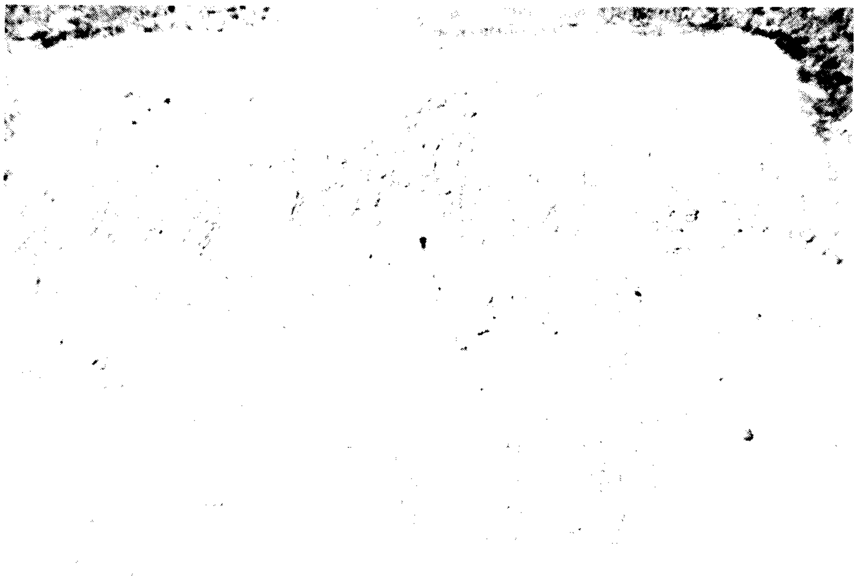


FIGURE 37
IMMEDIATELY AFTER PLACEMENT

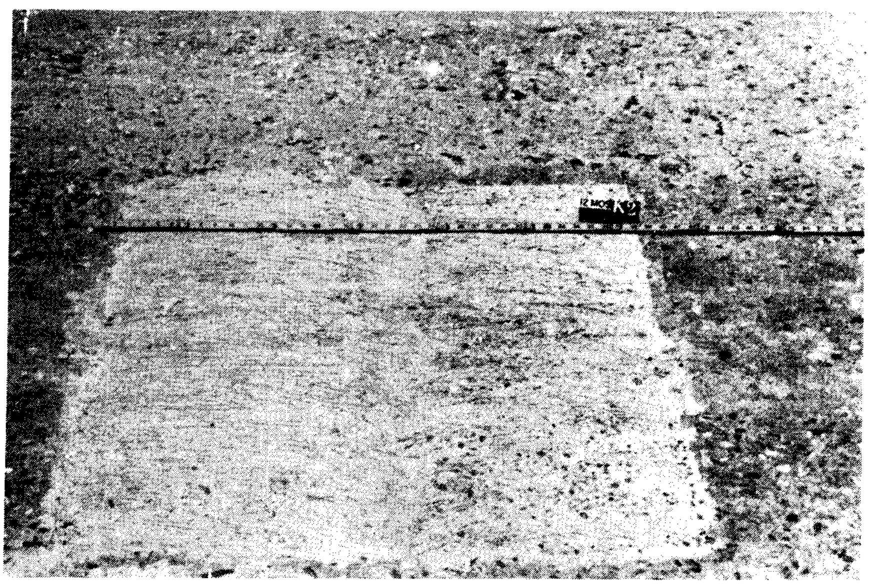


FIGURE 38
AFTER ONE YEAR OF TRAFFIC

PATCH K-3

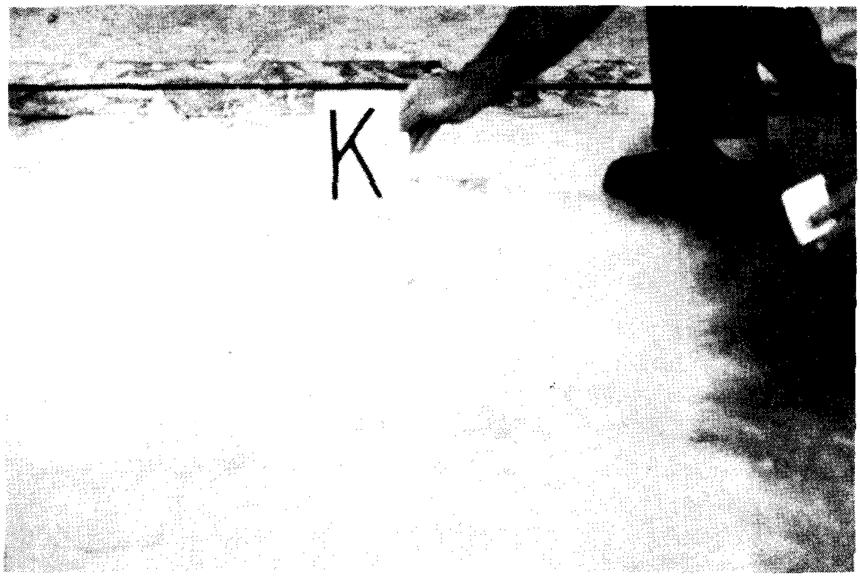


FIGURE 39
IMMEDIATELY AFTER PLACEMENT

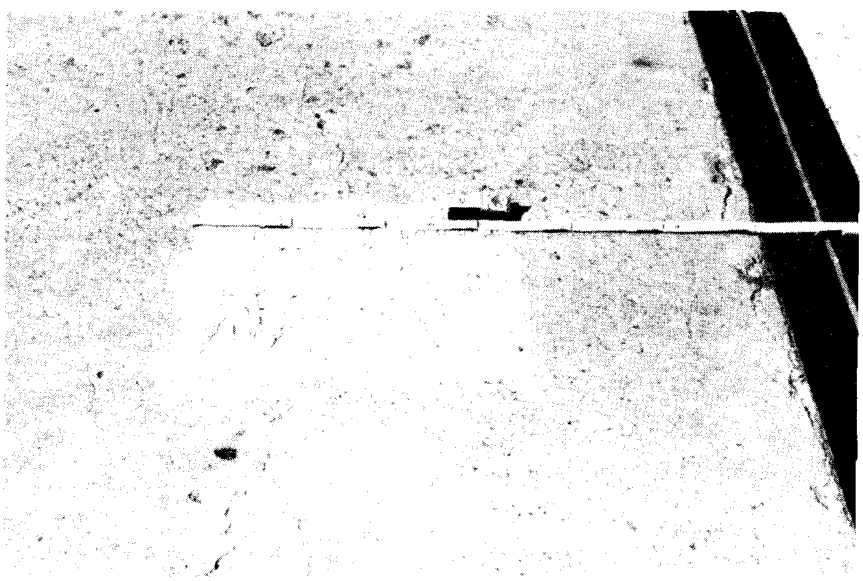


FIGURE 40
AFTER ONE YEAR OF TRAFFIC

PATCH K-4

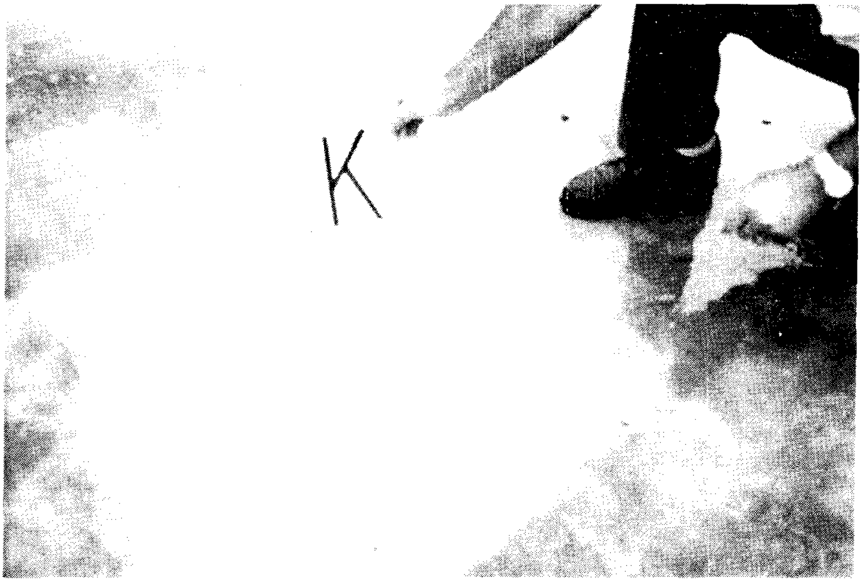


FIGURE 41
IMMEDIATELY AFTER TREATMENT

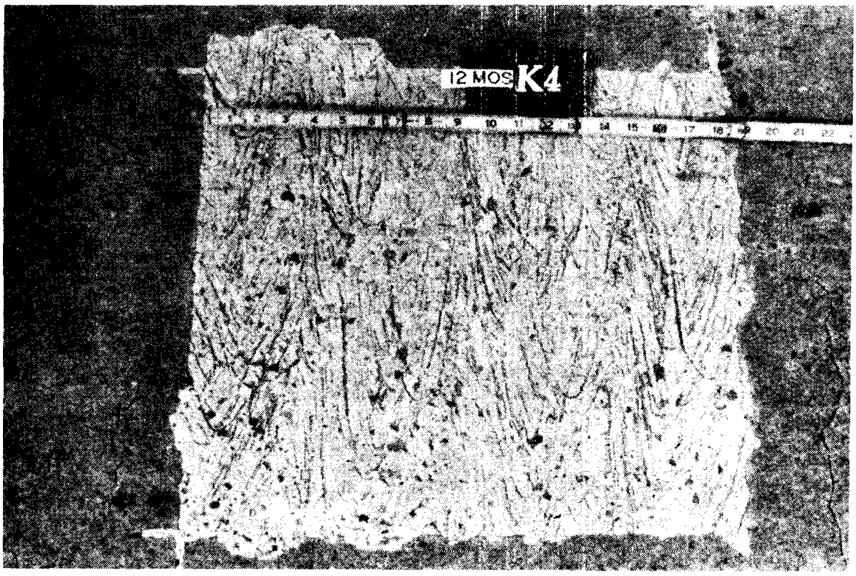


FIGURE 42
AFTER ONE YEAR OF TRAFFIC

PATCH K-5

FIGURE 43
IMMEDIATELY AFTER PLACEMENT

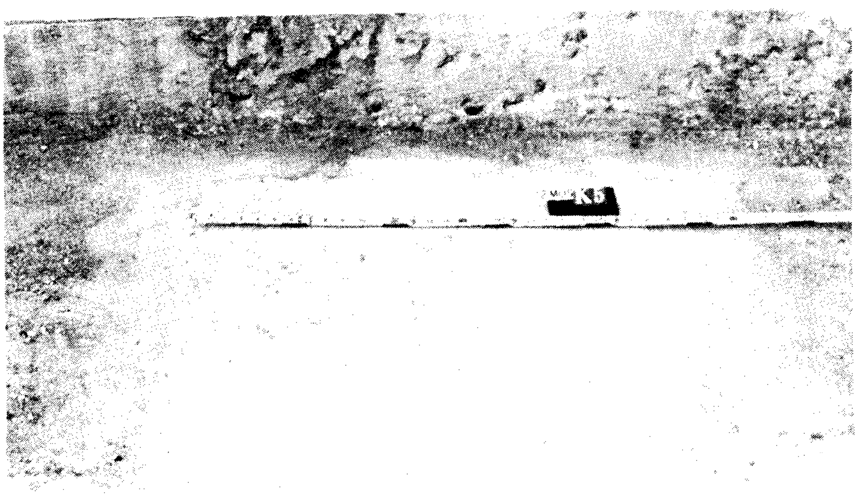


FIGURE 44
AFTER ONE YEAR OF TRAFFIC

PATCH L-1

FIGURE 45
IMMEDIATELY AFTER PLACEMENT

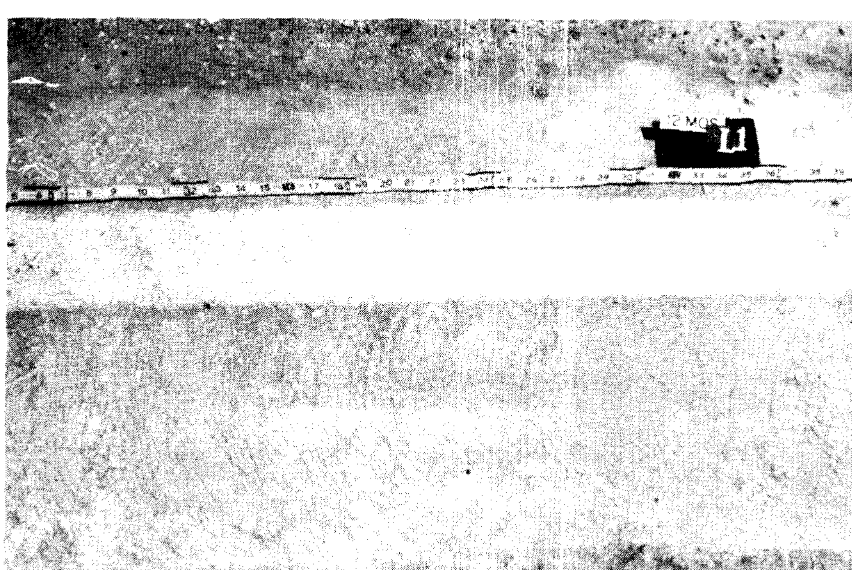


FIGURE 46
AFTER ONE YEAR OF TRAFFIC

PATCH L-2

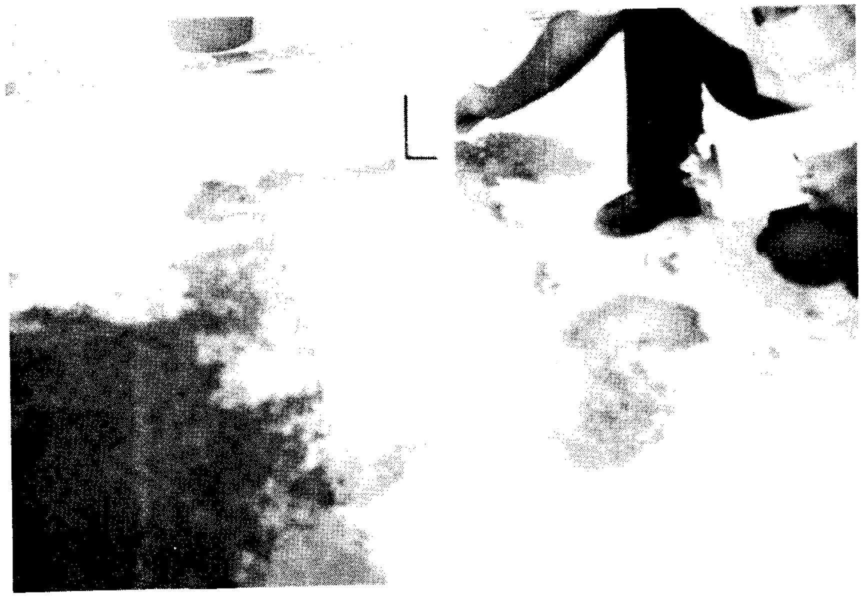


FIGURE 47
IMMEDIATELY AFTER PLACEMENT

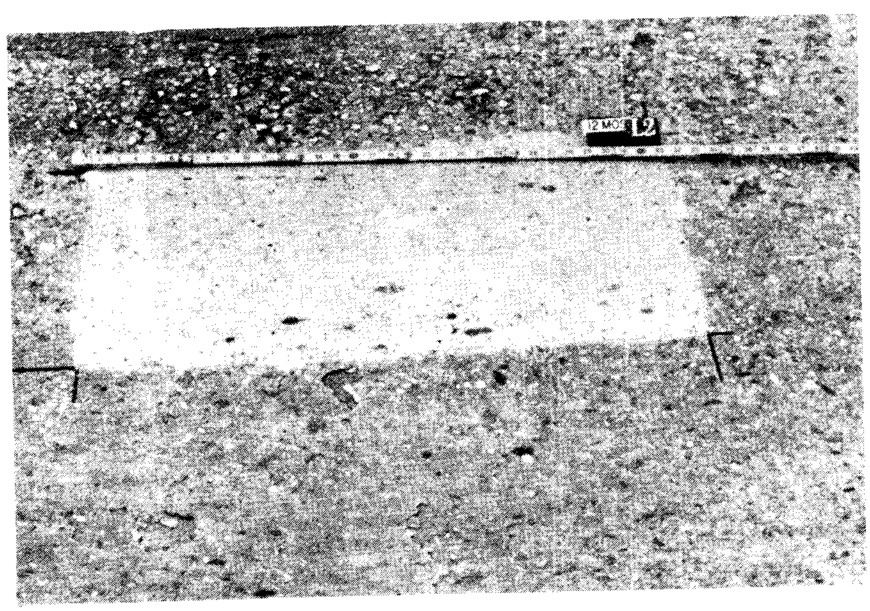


FIGURE 48
AFTER ONE YEAR OF TRAFFIC

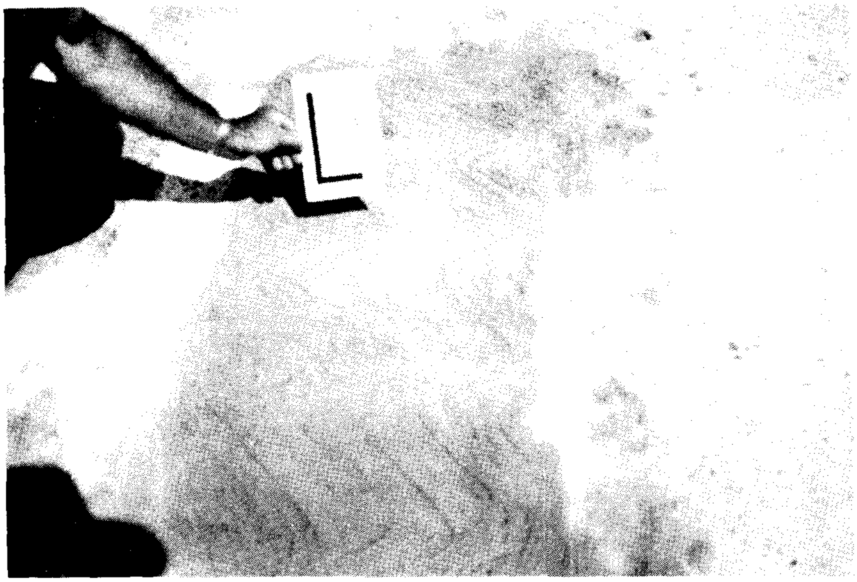


FIGURE 51
IMMEDIATELY AFTER PLACEMENT

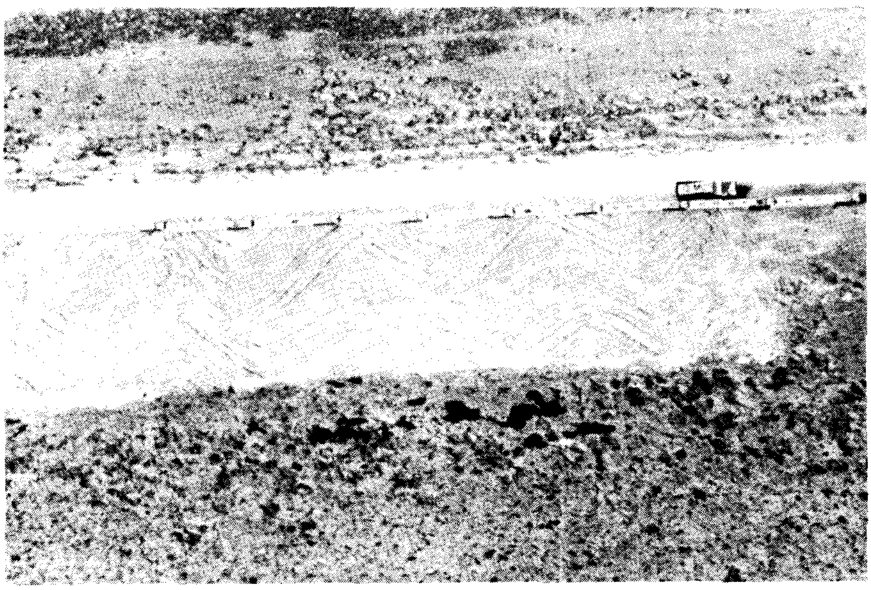


FIGURE 52
AFTER ONE YEAR OF TRAFFIC

PATCH L-5

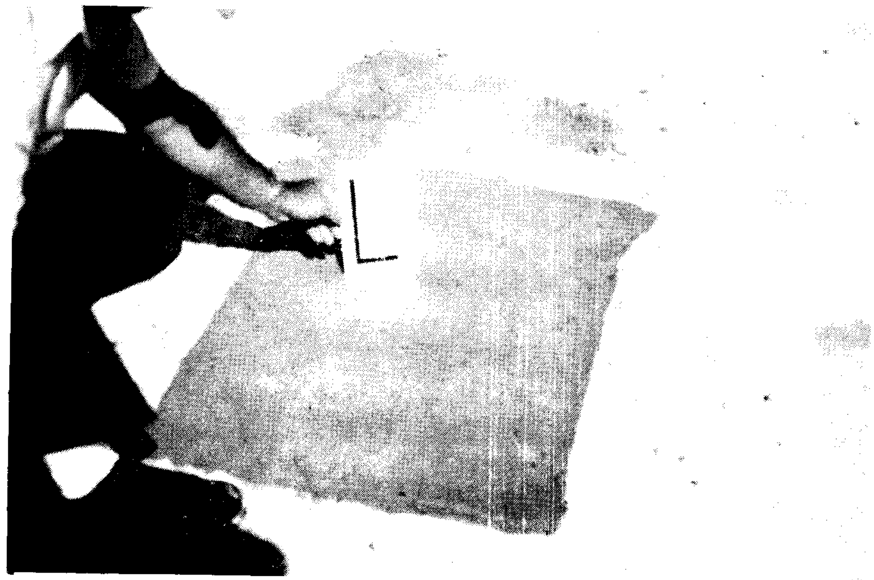


FIGURE [illegible]
IMMEDIATELY AFTER PLACEMENT

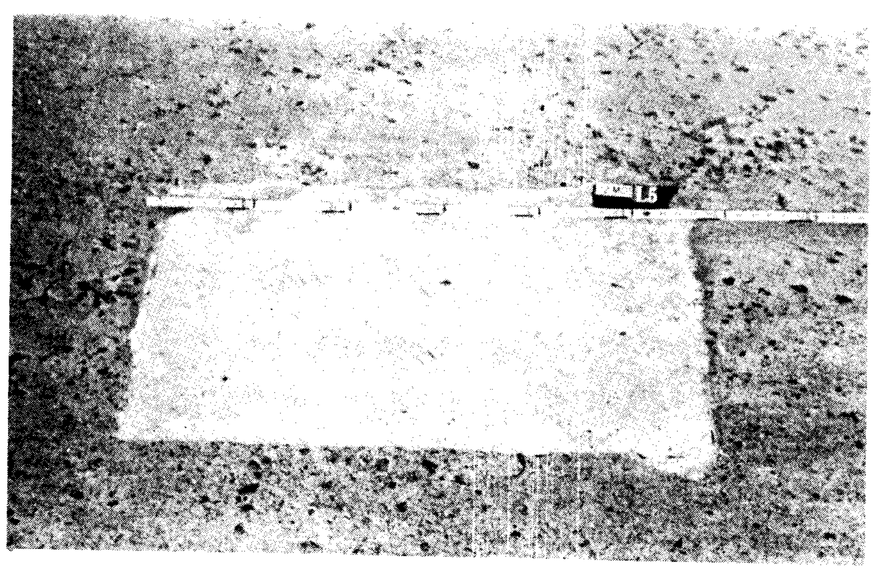


FIGURE [illegible]
AFTER ONE YEAR OF TRAFFIC

PATCH M-1

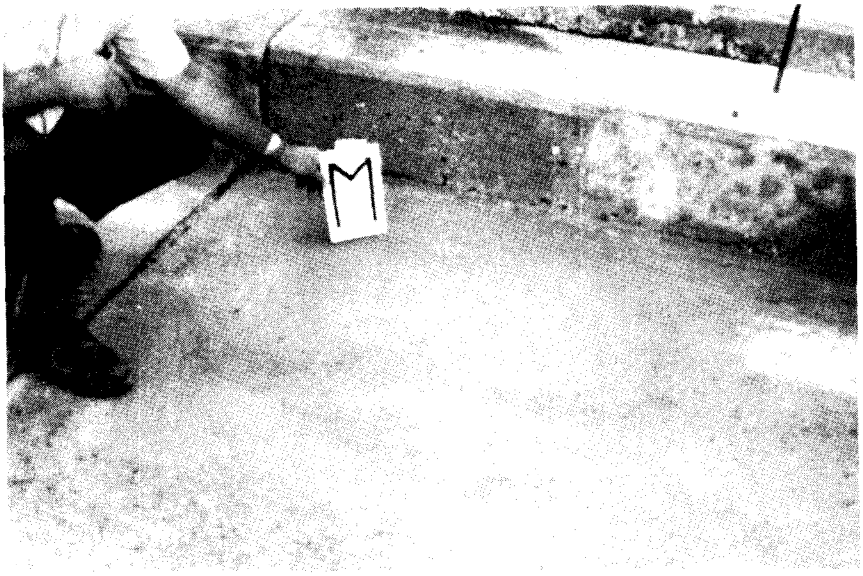


FIGURE 55
IMMEDIATELY AFTER PLACEMENT

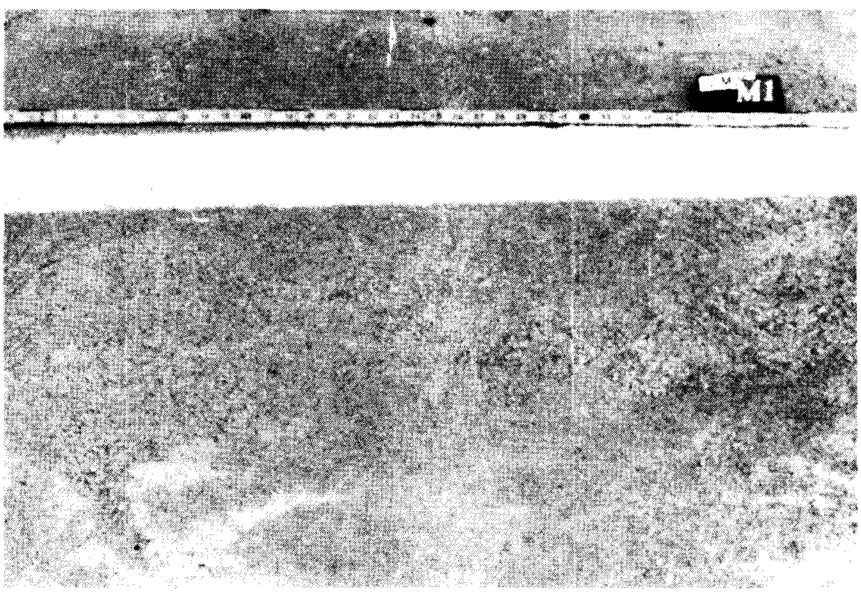
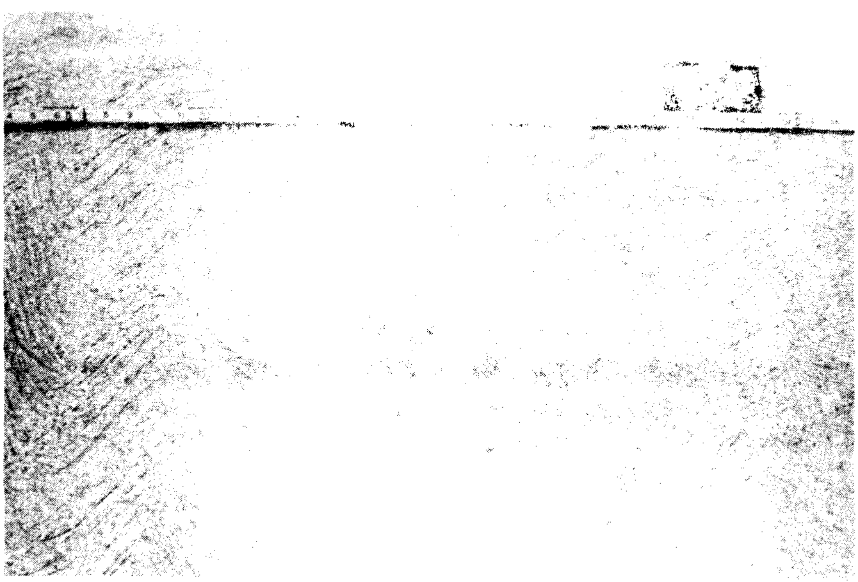


FIGURE 56
AFTER ONE YEAR OF TRAFFIC



PATCH M-3

FIGURE 59
IMMEDIATELY AFTER PLACEMENT

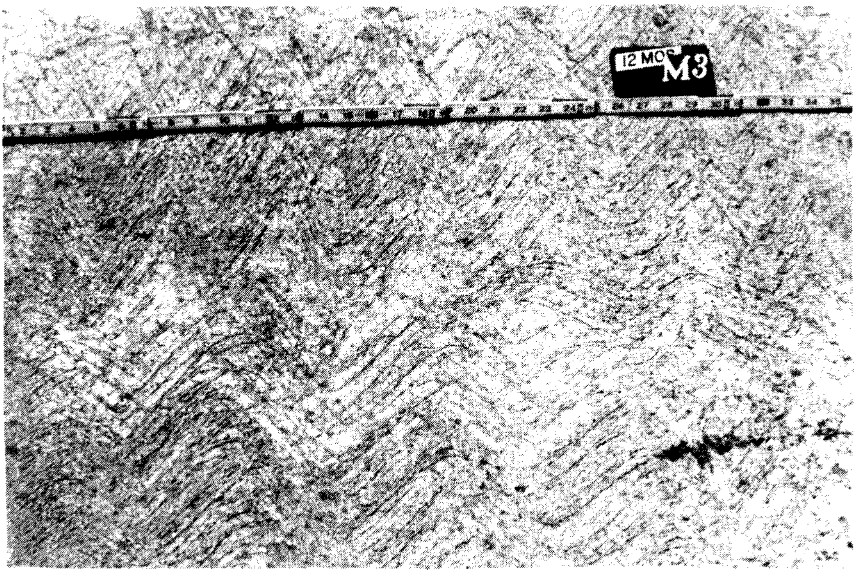


FIGURE 60
AFTER ONE YEAR OF TRAFFIC

PATCH M-4

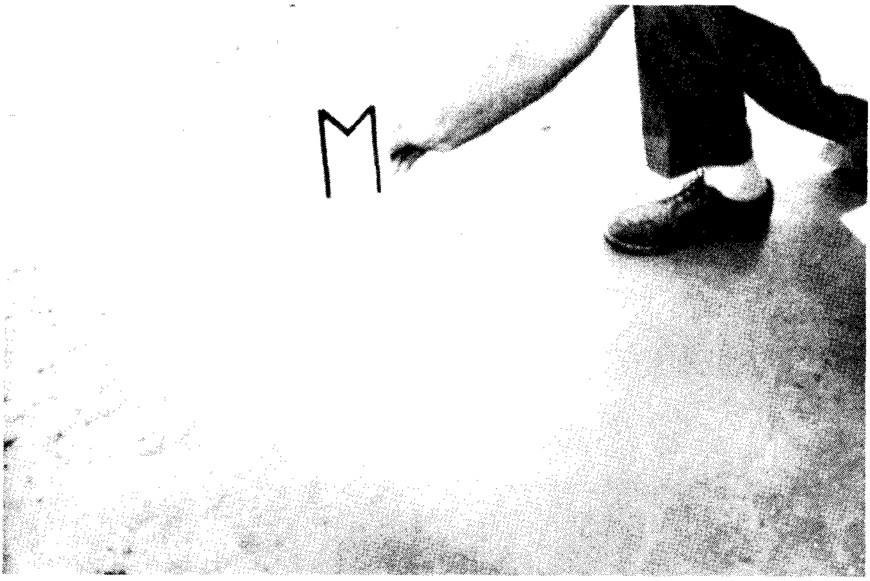


FIGURE 61
IMMEDIATELY AFTER PLACEMENT

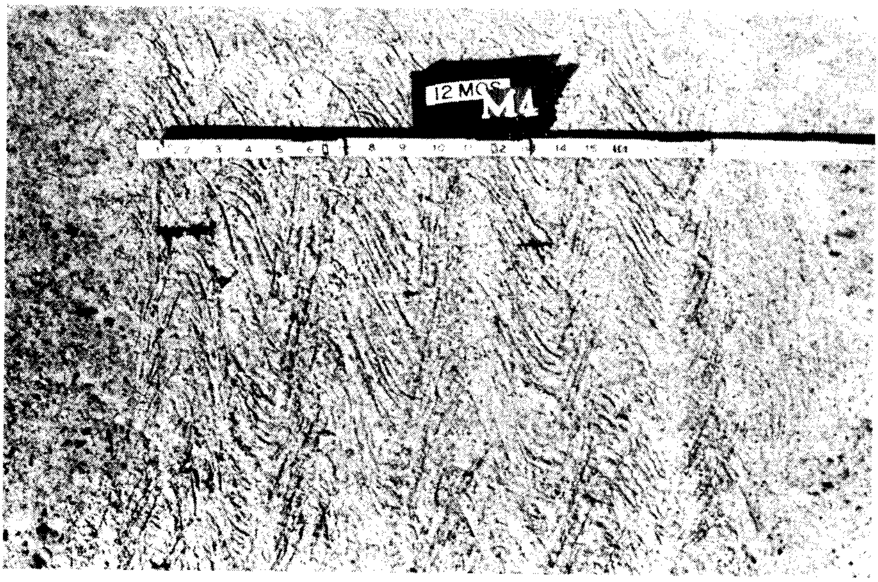


FIGURE 62
AFTER ONE YEAR OF TRAFFIC

PATCH M-5

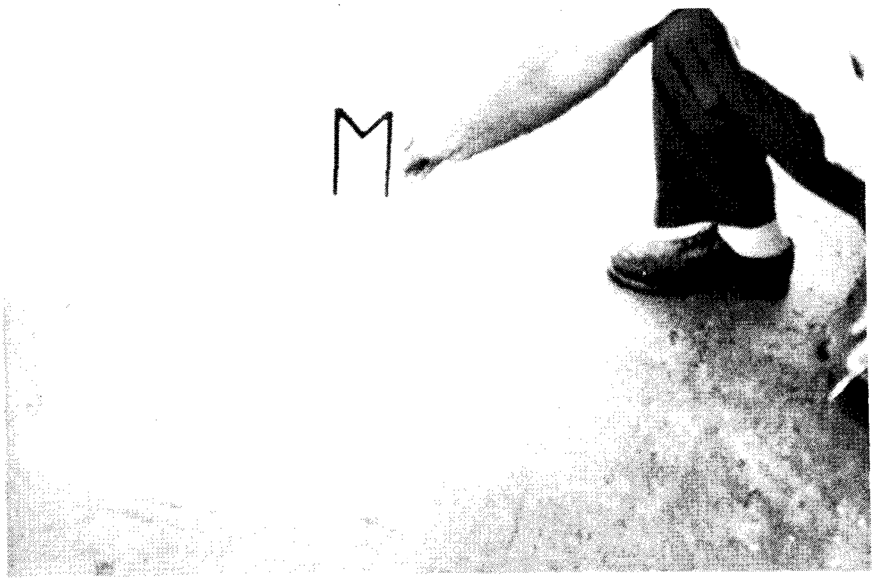


FIGURE 63
IMMEDIATELY AFTER PLACEMENT

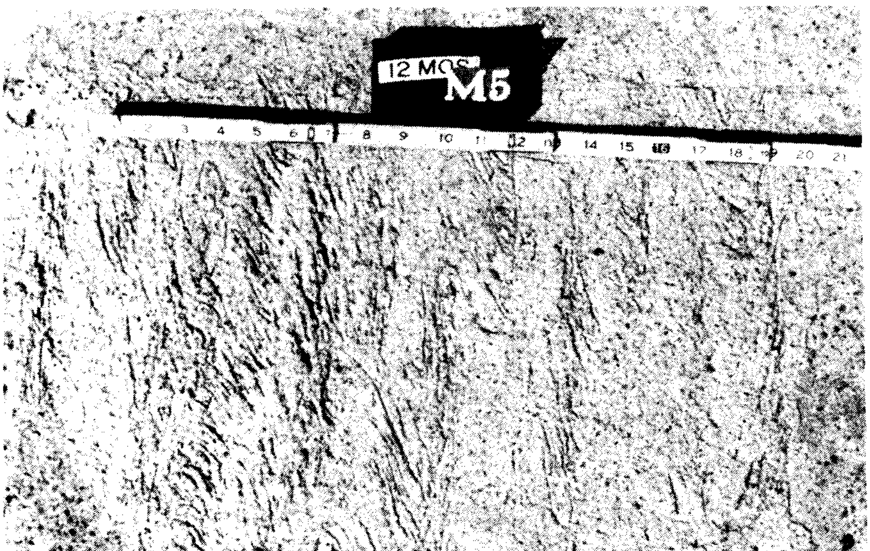


FIGURE 64
AFTER ONE YEAR OF TRAFFIC

PATCH N-1

FIGURE 65
PRIOR TO PLACEMENT

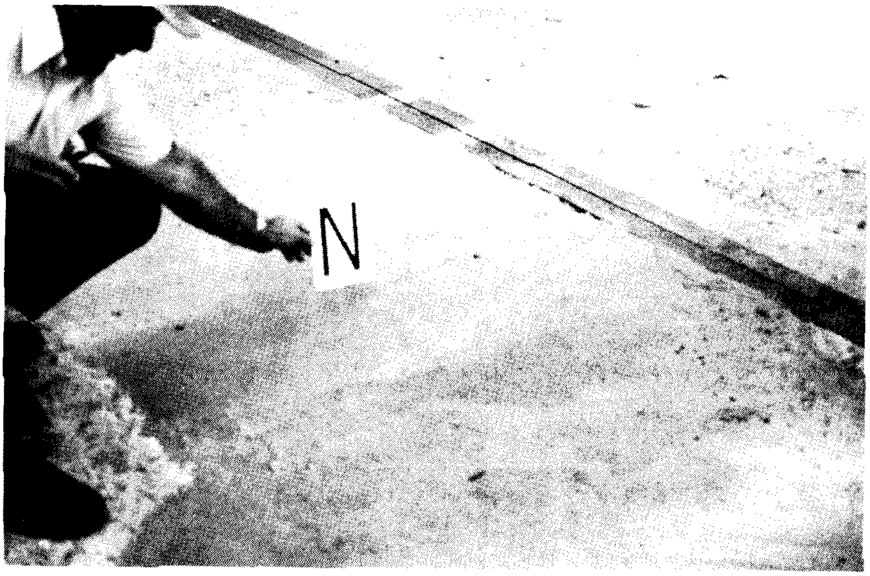


FIGURE 66
IMMEDIATELY AFTER PLACEMENT

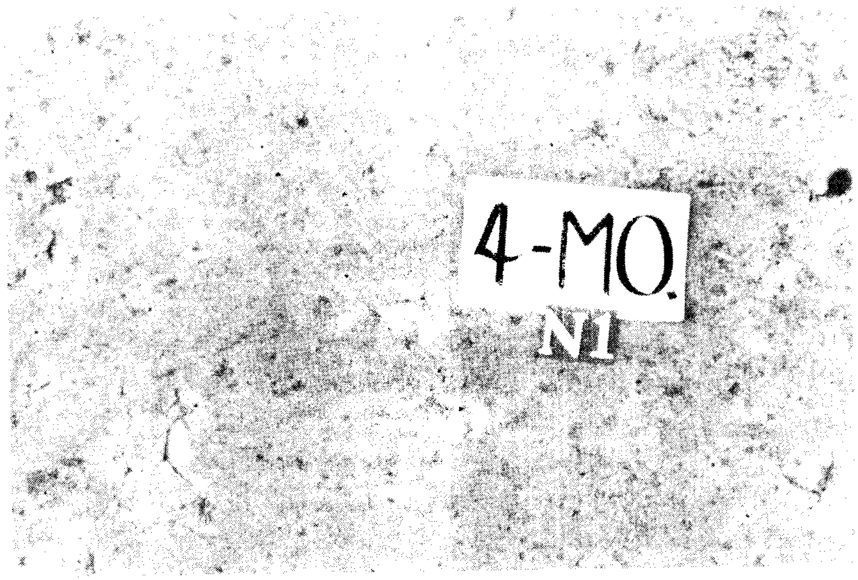


FIGURE 65
AFTER FOUR MONTHS OF TRAFFIC

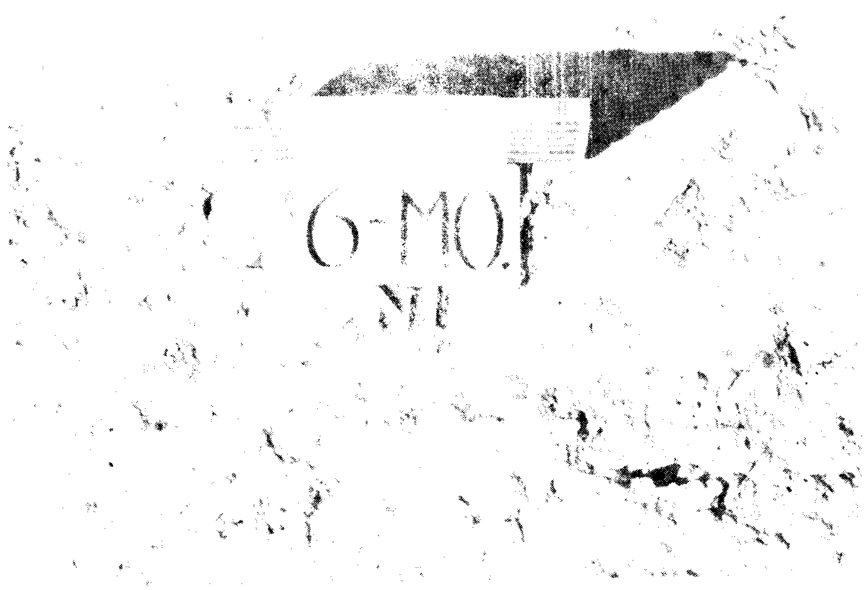


FIGURE 66
AFTER SIX MONTHS OF TRAFFIC

[illegible]
AFTER TEN MONTHS OF TRAFFIC

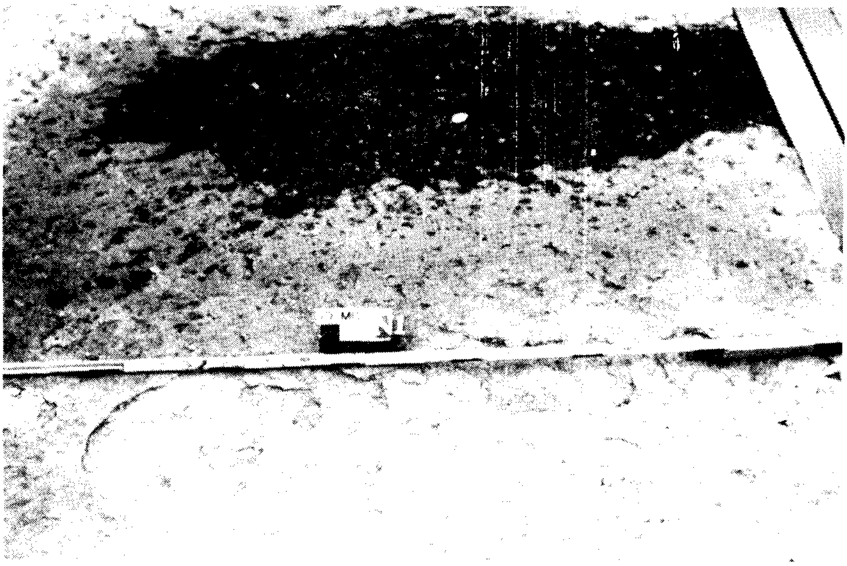


FIGURE 70
AFTER TEN MONTHS OF TRAFFIC

PATCH N-1

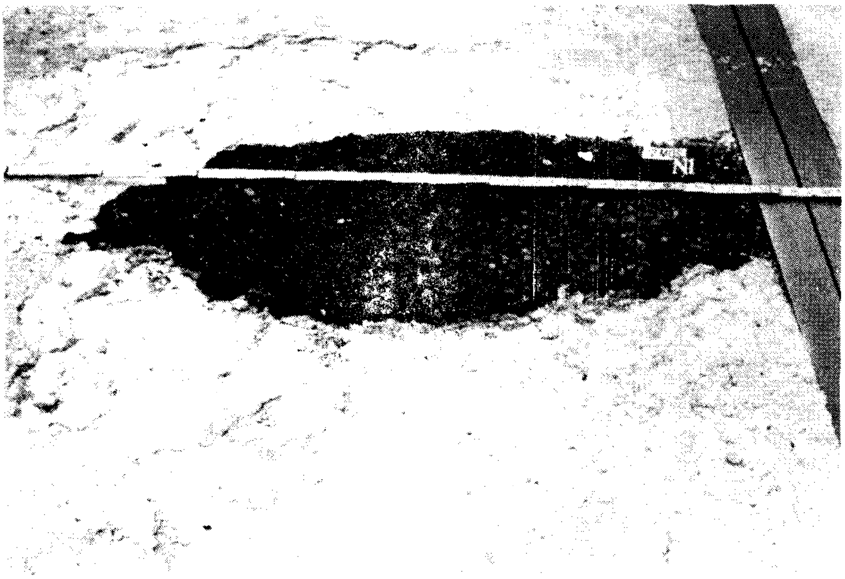


FIGURE [illegible]
AFTER ONE YEAR OF TRAFFIC

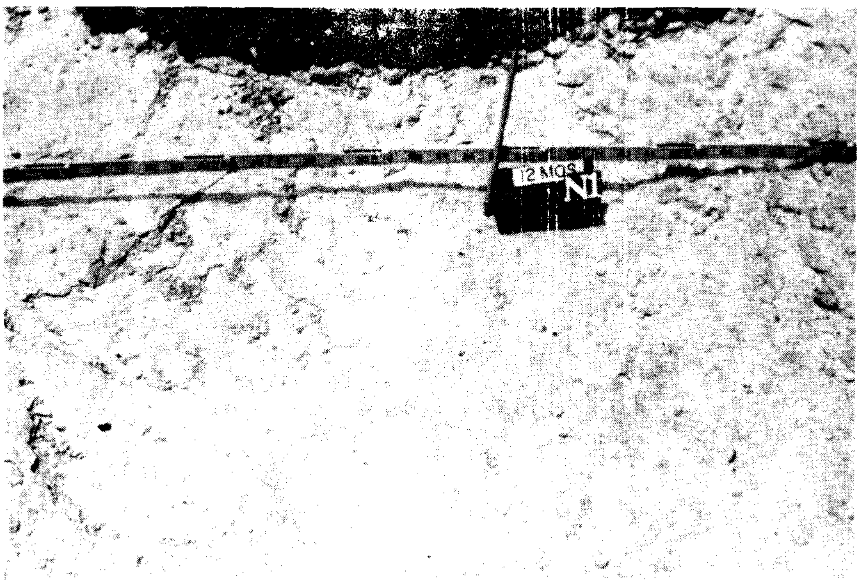
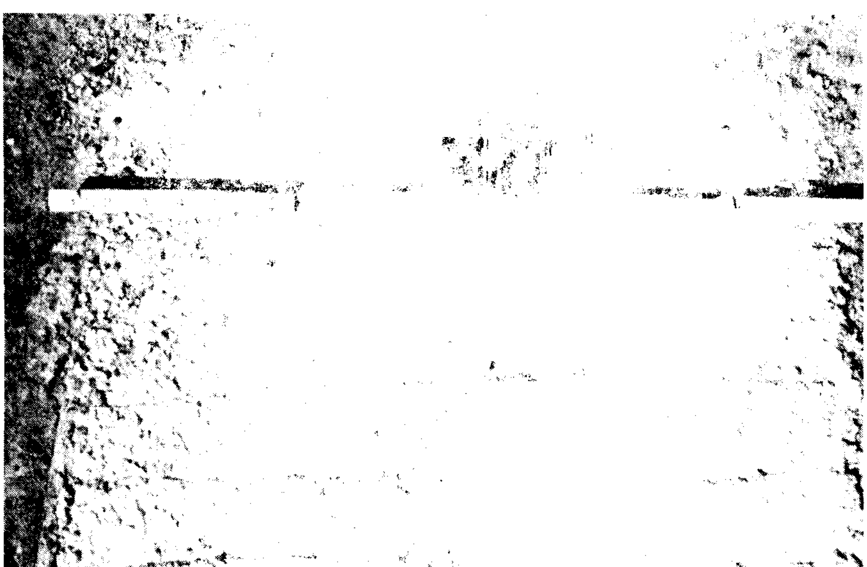


FIGURE [illegible]
AFTER [illegible] TRAFFIC



Additional material was shipped for further evaluation. Laboratory testing was performed and field patches were placed; however, the results of that testing are not complete and will not be reported here.

RECOMMENDATIONS

It is recommended that Systems J, K, L and M be allowed for patching pavements and bridge decks and that the following procedures be implemented for acceptance of patching materials.

1. All new products should be submitted to and screened by the New Products Evaluation Committee.

2. Each material, after assignment by the New Products Evaluation Committee, should be examined for chloride content and, any product which contains an amount of chloride in excess of the departmental standards should be rejected at that point.

3. If excessive chlorides are not present, the basic properties of the patching material should be determined through laboratory mixing and testing. These properties should include set time, working time, freeze and thaw durability, and 6-hour, 24-hour and 28-day strengths. Only the manufacturer's printed instructions should be used in mixing the products.

4. If either the early strengths or the durability prove to be grossly deficient, the results should be sent back to the New Products Evaluation Committee for rejection.

5. If the results are positive, the material should then undergo a one-year field durability evaluation under traffic conditions prior to acceptance. These test patches should be placed on a bridge in the northern section of the state. It is recommended that maintenance forces apply a minimum of four patches, using their normal techniques.

6. The field test patches should be observed and photodocumented during their testing period; and at the conclusion of one year, the results should be reported to the New Products Evaluation Committee for their action.

7 A Qualified Products List should be kept on products that have proved to be acceptable materials for patching roads and bridge decks.