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THE RESISTANCE OF POROUS ASPHALT AND ANTIHYDROPLANING SURFACES TO ENVIRONMENTAL EFFECTS AND SIMULATED AIRCRAFT WHEEL LOADINGS

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The resistance of test strips of porous asphalt and several other antihydroplaning surfaces to environmental effects and simulated aircraft wheel loadings is described. The report shows that porous asphalt and porous asphalt with a rubber additive are the most promising antihydroplaning materials currently available and that, for various reasons, the other antihydroplaning surfaces tested were marginally acceptable or unacceptable.

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SECTION I

INTRODUCTION

The increased demand for an all-weather operation of military and commercial aircraft has focused attention on the phenomenal interaction that develops between high-speed pneumatic tires and wet pavement surfaces commonly described as hydroplaning (ref. 1). This condition of hydroplaning may vary from low-level viscous hydroplaning or thin-film lubrication to dynamic hydroplaning which may consist of a virtual separation of the tire from the pavement surface. These varying conditions of hydroplaning may reduce, or completely nullify, the development of a level of frictional force between the tire and pavement surface that is required for directional control and braking of high-speed aircraft. This threat to the safe operation of military and commercial aircraft gave rise to a special research effort at the Air Force Weapons Laboratory (AFWL) for the improvement and/or development of overlays to minimize the threat of hydroplaning. This report furnishes a brief description of the antihydroplaning test surfaces constructed by AFWL and the Civil Engineering Research Facility (CERF) of the University of New Mexico, and a preliminary report on the resistance of these surfaces to environmental effects and simulated aircraft wheel loadings.

The research work conducted by AFWL and CERF consisted of preliminary laboratory testing and the construction of test strips within three field test areas at the Albuquerque International Airport (Kirtland Air Force Base). The location of the three test areas is shown in figure 1. The test strips in test area 1 (constructed September 1971) consist of porous asphalt overlays with variations in asphalt binder and aggregate gradation. The test strips in test areas 2 and 3 (constructed in September and October 1973) consist of asphalt slurry, an epoxy binder with an abrasive material included (Palmer Pavetread), porous asphalt cold mix, and porous asphalt hot mix prepared with a binder consisting of asphalt cement and latex rubber (ref. 2).

Test area 1 was located within an active portion of taxiway 1, so that the test surfaces could be subjected to environmental conditions, taxiing aircraft, traffic with simulated aircraft-wheel loadings, and friction measurements with

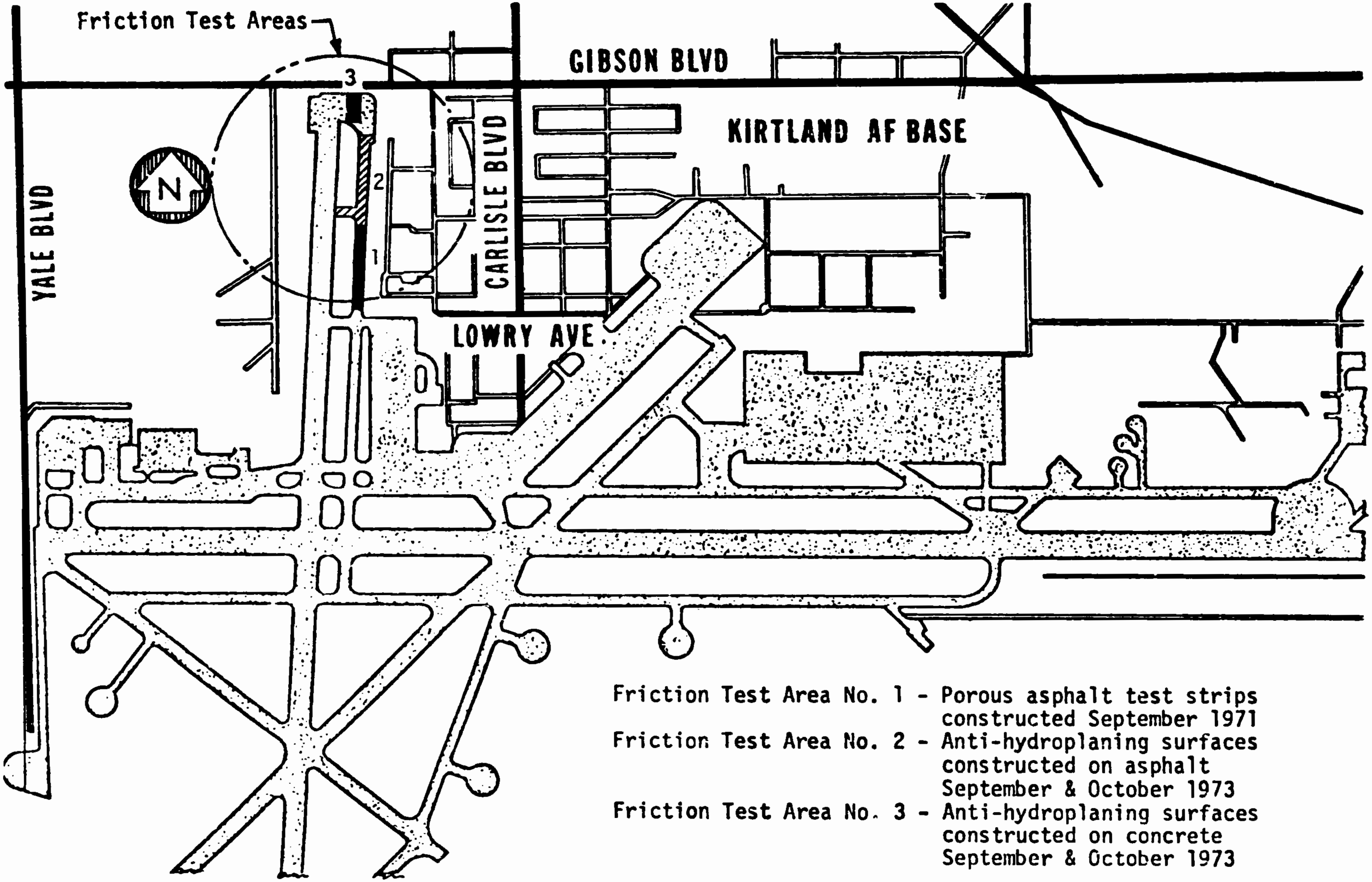


Figure 1. Location of Friction Test Areas 1, 2, and 3

the mu-meter and diagonally braked vehicle. The test strips within test area 2 were designed primarily for an evaluation of the bonding characteristics of the overlay materials on an existing asphalt pavement, resistance to the exposure to environmental conditions, and friction measurements with the mu-meter and diagonally braked vehicle. The test strips within test area 3 were designed primarily for an evaluation of the bonding characteristics of the overlay materials on existing concrete pavement, and resistance to environmental conditions.

This report contains a brief discussion of the field tests and the data collected to date for a study of

a. Resistance of porous asphalt test strips (test area 1) to environmental conditions.

b. Resistance of porous asphalt test specimens to cycles of freezing and thawing (laboratory test).

c. Resistance of porous asphalt and antihydroplaning surfaces (test areas 2 and 3) to environmental conditions.

d. Resistance of porous asphalt (test area 1) and antihydroplaning test surfaces (test area 2) to traffic with simulated aircraft-wheel loadings.

SECTION II

RESISTANCE OF POROUS ASPHALT TO ENVIRONMENTAL EFFECTS

During September of 1971 a series of porous asphalt test strips was constructed on taxiway 1 at the Albuquerque International Airport for the purpose of conducting a field evaluation of the characteristics of various porous asphalt overlay mixes reflecting variations in asphalt binder and aggregate gradation. Figure 2 shows the layout of the test strips and variations in asphalt binder. The specifications for the eight test strips are included in the appendix. A description of the observations and data collected regarding the resistance of these porous asphalt overlays to environmental effects is included in this section.

The method used for the evaluation of the resistance to the environmental effects included: (1) a determination of the hardening effects, or change in the penetration of the asphalt binders, (2) freeze-thaw tests, and (3) a visual inspection of the performance of the test surfaces under limited air traffic and actual weather conditions. The test data and evaluations obtained in the previously described areas are as follows.

1. HARDENING OF ASPHALT

Since a large percentage of the asphalt binder in porous asphalt mixes is exposed to the weathering elements, valid questions have been raised about the rate of hardening or aging of the asphalt. Table 1 shows the penetration of the asphalt binders at the time of construction and at the end of a 29-month service period (September 1971 to February 1974).

Additional control data were determined regarding the viscosity of the asphalt binders at different temperatures. Table 2 shows the vacuum viscosity as determined at 140°F, 210°F, and 275°F by Chevron Research Company, Richmond, California.

2. FREEZE-THAW TESTS

Field tests were also conducted for a determination of the resistance of the porous asphalt mixes to cycles of freezing and thawing. The field testing was accomplished by constructing small dikes or dams on the pavement surface that

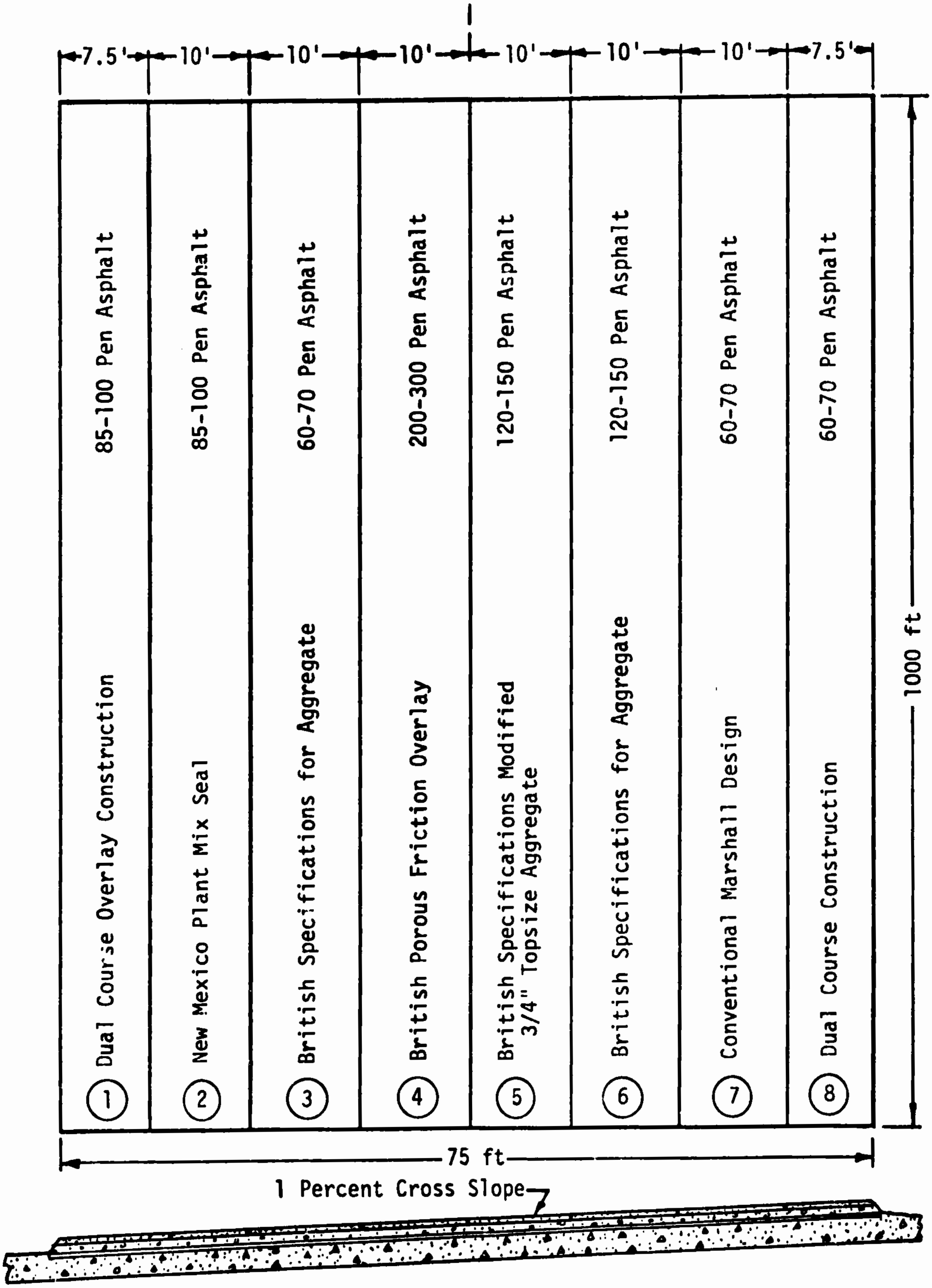


Figure 2. Porous Asphalt Test Strips, Friction Test Area No. 1

Table 1

PENETRATION OF ASPHALT BINDERS

Test Strip	Type of Asphalt	Original Penetration	Penetration After 29 mo.
1	AC 85-100	94	42
2	AC 85-100	94	44
3	AC 60-70	65	28
4	AC 200-300	227	38
5	AC 120-150	130	47
6	AC 120-150	130	40
7	AC 60-70	65	18
8	AC 60-70	65	20

Table 2

VACUUM VISCOSITY AT DIFFERENT TEMPERATURES

	Identification			
University of New Mexico Chevron Research	60/70	85/100	120/150	200/300
Viscosity at 140°F, Poise	1820	1100	755	281
Viscosity at 210°F, Poise	27.7	22.1	17.3	8.12
Viscosity at 275°F, Poise	3.11	2.65	2.22	1.18

Chevron Research Company, Richmond, California LNM, 3-3-72.

were filled with water during cold weather. This condition was designed to simulate the freeze-thaw activity existing within poorly drained areas on existing pavement surfaces. Figure 3 shows the ponding areas as constructed for the freeze-thaw tests. Table 3 shows the days that the ponding areas were filled with water (freeze-thaw cycles) and the minimum daily temperature as obtained from local climatological data sheets.

Figure 3. Ponding Areas for Freeze-Thaw Tests (Test Area No. 1)

3. LIMITED AIR TRAFFIC AND ENVIRONMENTAL EFFECTS

The periodic visual inspections of the porous asphalt test surfaces during the past 2-1/2 years have not disclosed any signs of distress or deterioration resulting from the combined effects of weather and air traffic. All of the test surfaces (eight test strips) have demonstrated a high level of performance during the observation period. The principal changes in the surface conditions

Table 3

CYCLES OF FREEZING AND THAWING ON POROUS ASPHALT TEST STRIPS (Test Area 1)

Date	Minimum Daily Temperature* (°F)	Accumulative Cycles of Freeze-Thaw
1-29-73	17	1
1-30-73	16	2
1-31-73	26	3
2-1-73	23	4
2-2-73	14	5
2-5-73	30	6
2-8-73	20	7
2-9-73	19	8
2-10-73	20	9
2-11-73	26	10
2-12-73	26	11
2-13-73	21	12
2-14-73	25	13
2-15-73	23	14
2-16-73	27	15
2-19-73	26	16
2-21-73	30	17
2-22-73	27	18
2-23-73	29	19
2-26-73	27	20
3-6-73	26	21

*From Local Climatological Data, US Department of Commerce.

consist of (1) the development of surface cracks, and (2) erosion of asphalt from the exposed particles of aggregate. These two changes in surface conditions are normally expected from in-service bituminous overlays.

Since the taxiway, including the test strips, serves the secondary runway, the air traffic has consisted primarily of general aviation and a limited amount of military and commercial traffic. The types of aircraft used for commercial aircraft consist of Convair 690, Boeing 737, Boeing 727, and Douglas DC-9. The porous asphalt test strips have resisted the taxiing of the above described aircraft during the past 2-1/2 years without showing any signs of raveling or deterioration.

SECTION III

RESISTANCE OF POROUS ASPHALT TO CYCLES OF FREEZING AND THAWING

A limited program of laboratory testing was conducted for the purpose of obtaining some measure of the resistance of porous asphalt to cycles of freezing and thawing. The laboratory testing consisted of the determination of the loss in unconfined compressive strength and Marshall stability due to cycles of freezing and thawing. The laboratory testing and test results are described in the following paragraphs.

1. UNCONFINED COMPRESSION TESTS (REF. 3)

Unconfined compression testing was selected as an expedient test method for evaluating loss in strength of porous asphalt due to cycles of freezing and thawing. In order to satisfy the recommended height/diameter ratio of 2 to 1 for unconfined compression test specimens, it was necessary to prepare special compaction molds and develop an acceptable compaction procedure. Split molds 5 inches in diameter and 10 inches in length were designed and fabricated for the preparation of large test specimens. An assembly diagram of the large split molds is shown in figure 4. The Marshall hammer modified with a special compaction foot attachment (figure 5) was used for compaction. The compaction foot attachment was designed with a chamfered face so as to minimize wall friction during compaction.

The test specimens were prepared by compacting the porous asphalt in the heated molds in four layers with 25 blows per layer. After compaction, the collar was removed from the mold assembly, and the top of the test specimen was finished with a heated trowel. The test specimens were left in the molds for at least 12 hours to ensure thorough cooling and hardening. After the test specimens were removed from the molds, weight-per-unit-volume was obtained by dividing the weight of the test specimen by the volume of the mold. Test specimens were prepared in sets of six so that three test specimens could be used for control and three for freeze/thaw cycling.

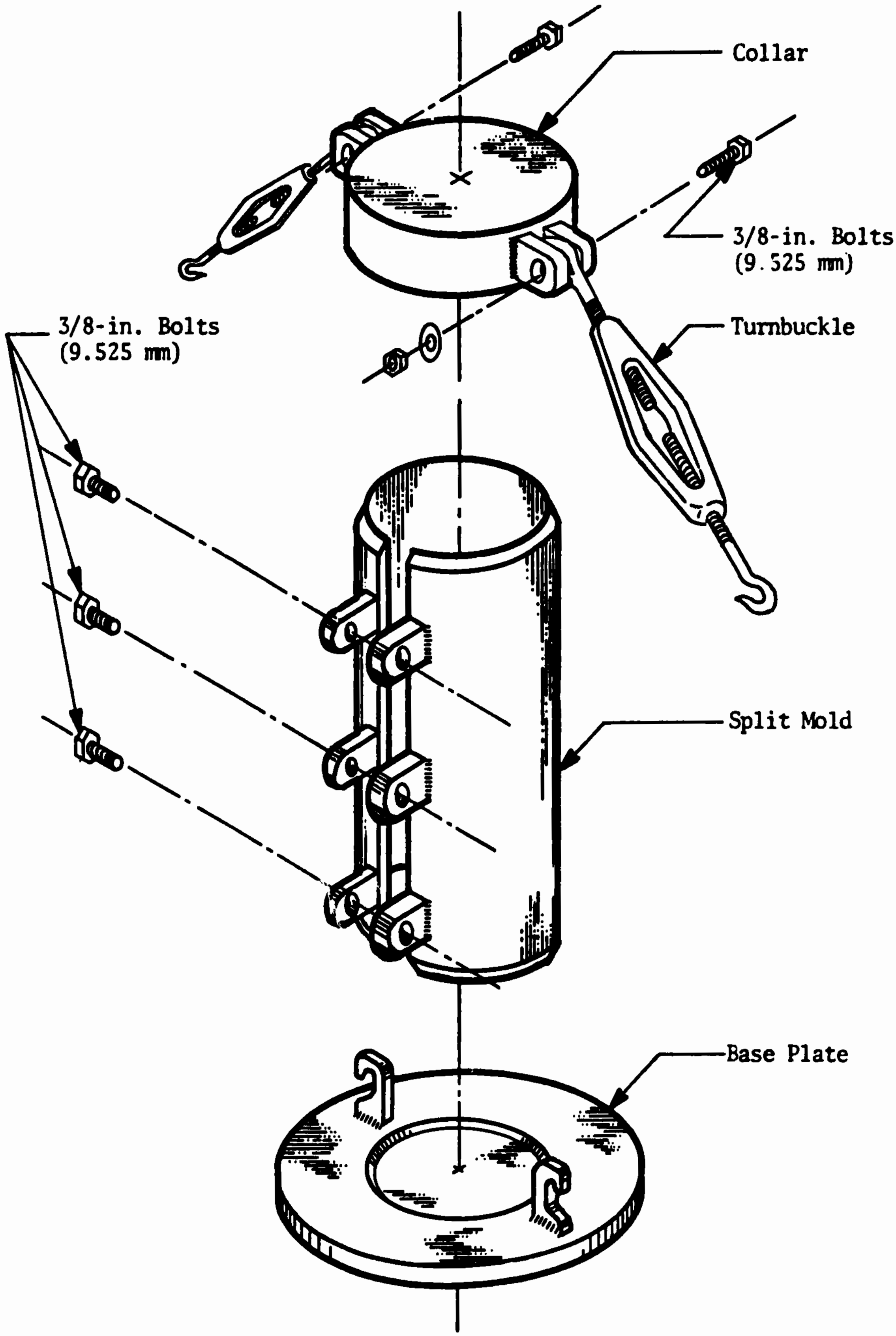


Figure 4. Compaction Mold Assembly

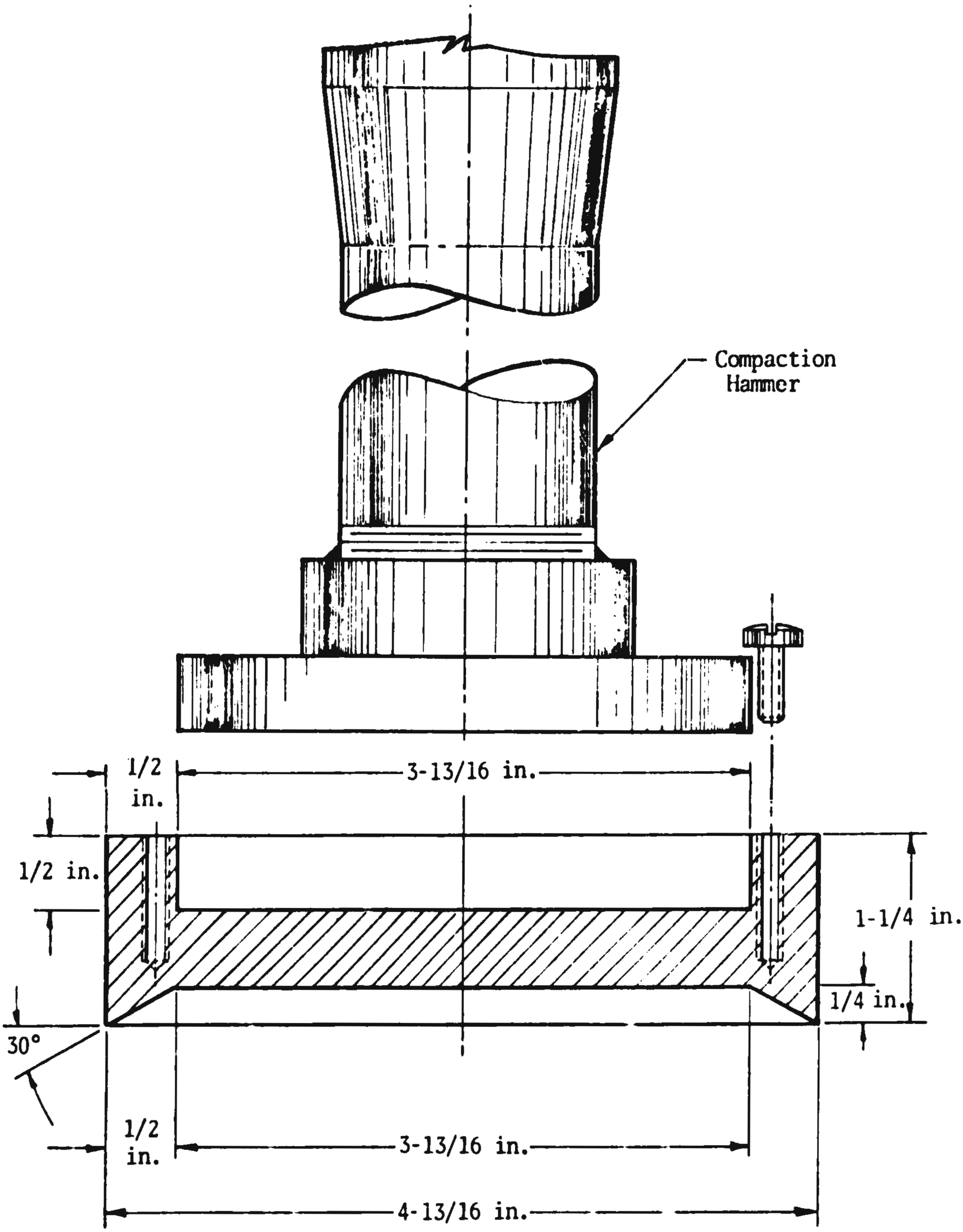


Figure 5. Marshall Hammer with Compaction Foot Attachment

Freezing and thawing were accomplished by soaking the test specimens in water during the day and placing them in a refrigerator at a temperature of -15°F or below during the night (and weekends). The specimens were allowed to drain for approximately 15 minutes prior to being placed in the refrigerator. Seventy-five freeze-thaw cycles were considered sufficient to reflect a relative measure of freeze-thaw damage.

The laboratory investigation consisted of a determination of unconfined compressive strengths for five variables in porous asphalt as well as the loss in compressive strength due to 75 cycles of freezing and thawing. The unconfined compressive strength was taken as the average of the test results from three control test specimens, whereas the loss in strength due to freeze/thaw damage was taken as the average of the test data from three companion test specimens after 75 cycles of freezing and thawing. All specimens were tested at room temperature and at a deformation rate of 0.05 in./min. Three additional test specimens were prepared from each type of binder for a study of the aging effects of the binder on compressive strength.

The test specimens were prepared in accordance with the previously described plan for sample preparation. The aggregate structure for all test specimens consisted of vesicular basalt graded in accordance with the following schedule.

Grade Fraction	Weight (%)
1/2 to 3/8 inch	10
3/8 inch to No. 4	40
No. 4 to No. 8	25
No. 8 to No. 200	20
No. 200 to pan	5

All test specimens were prepared with bituminous binder equal to 6 percent of the weight of the aggregate combination (5.66 percent of the total mix). The variables in bituminous binder and the unit weights of the compacted test specimens are given in table 4.

The specimens were subjected to strain-controlled unconfined compression testing at room temperature. Load-deformation readings were taken for each 0.025 inch of deformation. Freeze/thaw damage was determined by subtracting the

Table 4

VARIABLES IN BINDER AND
UNIT WEIGHTS OF COMPACTED TEST SPECIMENS

Specimen Number	Test Type	Type of Binder	Unit Weight (gm/cm^3)
1	Control	60-70 Penetration Asphalt	2.02
2	Freeze/thaw	60-70 Penetration Asphalt	1.98
3	Control	60-70 Penetration Asphalt	2.02
4	Freeze/thaw	60-70 Penetration Asphalt	1.99
5	Control	60-70 Penetration Asphalt	2.03
6	Freeze/thaw	60-70 Penetration Asphalt	2.02
7	Control	85-100 Penetration Asphalt	1.99
8	Freeze/thaw	85-100 Penetration Asphalt	2.01
9	Control	85-100 Penetration Asphalt	2.01
10	Freeze/thaw	85-100 Penetration Asphalt	2.00
11	Control	85-100 Penetration Asphalt	2.00
12	Freeze/thaw	85-100 Penetration Asphalt	2.00
13	Control	120-150 Penetration Asphalt	2.05
14	Freeze/thaw	120-150 Penetration Asphalt	2.06
15	Control	120-150 Penetration Asphalt	2.02
16	Freeze/thaw	120-150 Penetration Asphalt	2.05
17	Control	120-150 Penetration Asphalt	2.04
18	Freeze/thaw	120-150 Penetration Asphalt	2.04
19	Control	200-300 Penetration Asphalt	1.99
20	Freeze/thaw	200-300 Penetration Asphalt	1.99
21	Control	200-300 Penetration Asphalt	1.94
22	Freeze/thaw	200-300 Penetration Asphalt	1.99
23	Control	200-300 Penetration Asphalt	1.97
24	Freeze/thaw	200-300 Penetration Asphalt	1.97
25	Control	RT-10 Coal Tar	2.01
26	Freeze/thaw	RT-10 Coal Tar	2.00
27	Control	RT-10 Coal Tar	2.00
28	Freeze/thaw	RT-10 Coal Tar	2.01
29	Control	RT-10 Coal Tar	1.98
30	Freeze/thaw	RT-10 Coal Tar	1.96

unconfined compressive strength of the freeze/thaw specimens (average of three specimens) from the strength of the control test specimens. The strength loss is also reported as a percentage of the unconfined compressive strength of the control test specimens.

After obtaining 75 cycles of freezing and thawing, the control specimens and freeze/thaw specimens were tested the same day at room temperature. Table 5 shows a summary of unconfined compressive strengths as well as the percentage of the unconfined compressive strength that was lost due to freeze/thaw damage.

Table 5

STRENGTH LOSS RESULTING FROM 75 FREEZE/THAW CYCLES

Type of Binder	Unconfined Compressive Strength (psi)	Unconfined Compressive Strength After 75 Freeze/Thaw Cycles (psi)	Strength Loss (%)
60-70 Penetration Asphalt	164	114	30
85-100 Penetration Asphalt	90	63	30
120-150 Penetration Asphalt	75	57	24
200-300 Penetration Asphalt	35	15	56
RT-10 Coal Tar	37	16	58

A preliminary investigation of the aging effects of the bituminous binder was conducted by comparing the unconfined compressive strength of 1-day-old test specimens with the unconfined compressive strength obtained from companion test specimens after approximately 4 months of aging in the laboratory. Table 6 shows the unconfined compressive strengths obtained from 1-day-old test specimens along with the unconfined compressive strengths of companion test specimens after more than 4 months of aging.

Table 6

EFFECTS OF AGING ON UNCONFINED COMPRESSIVE STRENGTH

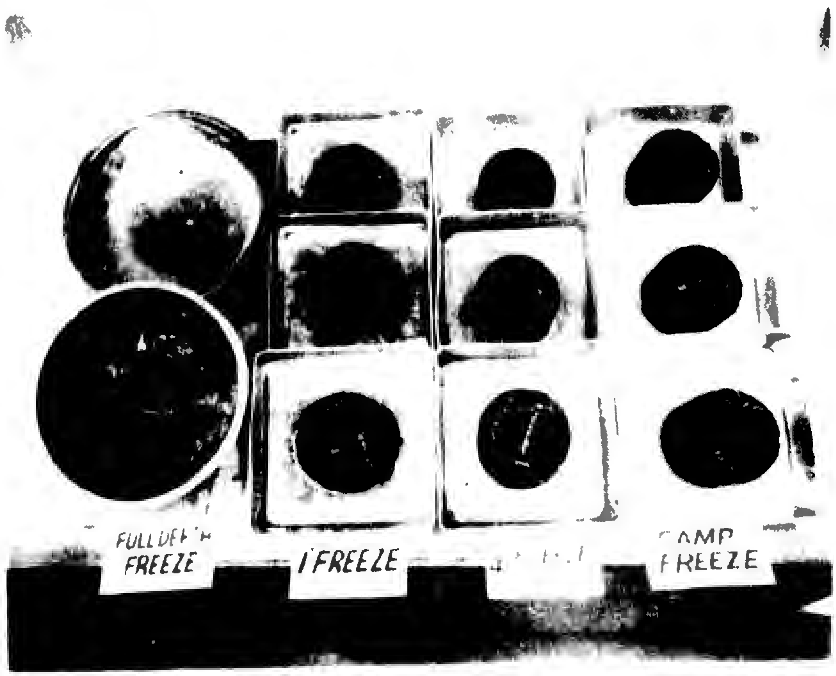
Type of Binder	Unconfined Compressive Strength 1 Day After Sample Preparation (psi)	Unconfined Compressive Strength After Aging	
		Aging Time (days)	Strength (psi)
60-70 Penetration Asphalt	137	156	144
85-100 Penetration Asphalt	123	127	90
120-150 Penetration Asphalt	58	145	75
200-300 Penetration Asphalt	43	115	35
RT-10 Coal Tar	23	134	57

The test data show a definite decrease in unconfined compressive strength with an increase in the penetration (penetration grade) of the asphalt cement binder. Test specimens prepared with 200-300 penetration asphalt yielded a very low unconfined compressive strength (35 psi) as well as a significant loss in strength (56 percent) after 75 cycles of freezing and thawing. The laboratory investigation of the aging effects of bituminous binders failed to show any significant increase in the unconfined compressive strength due to aging or hardening of the binder. The low level of unconfined compressive strength coupled with significant freeze/thaw damage and no appreciable strength increase due to aging point toward a questioned level of performance for porous asphalt mixes prepared with 200-300 penetration asphalt.

The program of laboratory testing also revealed unfavorable performance characteristics for the use of coal tar (RT-10) as a binder for porous bituminous mixes.

2. MARSHALL TESTS

For a further investigation of the resistance of porous asphalt to freeze-thaw damage, Marshall test specimens were prepared from two grades of asphalt cement for four levels of freeze tests. The test specimens were prepared from crushed basalt (graded in accordance with British, and Pease AFB specifications) and two grades of asphalt cement binder (200-300 and 120-150 pen). The four levels of freezing consisted of damp freeze, 1/4-inch submerged, 1-inch submerged, and fully submerged. Figure 6 shows the Marshall test specimens as subjected to the four levels of freezing. The test specimens were measured (mean diameter) before and after the 50 cycles of freezing and thawing. Table 7 contains a summary of the test data obtained from the laboratory testing of Marshall test specimens.



The test data in table 7 show a significant difference in the resistance to freeze-thaw damage due to the difference in asphalt binder. The stability of the porous asphalt prepared with 200-300 pen reduced considerably by 50 cycles of freezing and thawing; thereas, the porous asphalt prepared with 120-150 pen

Table 7

FREEZE-THAW TEST DATA, MARSHALL SPECIMENS

Specimens		Asphalt	Freeze Condition	Marshall Stability After 50 Cycles (lbs)	Increase in Diameter (in)	Marshall Stability of Control Spec. (lbs) (av. of 3)
58D	1	200-300	Damp	397	0.020	
58E	2	200-300	Damp	820	0.004	700
58F	3	200-300	Damp	915	0.012	
61D	4	200-300	¼" Water	Broke in Water Bath	0.037	
61E	5	200-300	¼" Water	Broke in Water Bath	0.009	700
61F	6	200-300	¼" Water	Broke in Water Bath	0.019	
62D	7	200-300	1" Water	Broke in Water Bath	0.021	
62E	8	200-300	1" Water	Broke in Water Bath	0.032	700
62F	9	200-300	1" Water	Broke in Water Bath	0.034	
58A	10	200-300	Submerged	Broke in Water Bath	0.016	700
58B	11	200-300	Submerged	Broke in Water Bath	0.014	
58C	12	200-300	Submerged	Broke in Water Bath	0.019	
57D	13	120-150	Damp	596	0.002	
57E	14	120-150	Damp	828	0.007	889
57F	15	120-150	Damp	747	0.004	
59D	16	120-150	¼" Water	626	0.003	
59F	17	120-150	¼" Water	646	0.002	889
59F	18	120-150	¼" Water	Broke in Water Bath	0.003	
60D	19	120-150	1" Water	626	0.005	
60E	20	120-150	1" Water	787	0.000	889
60F	21	120-150	1" Water	677	0.001	
57A	22	120-150	Submerged	Broke in Water Bath	0.005	
57B	23	120-150	Submerged	Broke in Water Bath	0.006	889
57C	24	120-150	Submerged	Broke in Water Bath	0.004	

retained a large percentage of the stability after the 50 cycles of freezing and thawing. The unconfined compression test data also show that porour asphalt prepared with 200-300 pen asphalt is more susceptible to freeze-that damage than porous asphalt prepared with 120-150 pen asphalt.

SECTION IV

RESISTANCE OF POROUS ASPHALT AND ANTIHYDROPLANING SURFACES TO ENVIRONMENTAL EFFECTS (TEST AREAS 2 AND 3)

Porous asphalt and antihydroplaning test surfaces (test areas 2 and 3) were constructed on taxiway 1 at the Albuquerque International Airport during September and October of 1973 for a continuation of the study of the performance of antihydroplaning overlays. Figures 7 and 8 show the surface types and dimensions of the test strips as constructed on asphalt and concrete pavement surfaces. The test surfaces were constructed on asphalt and concrete for a field evaluation of the bonding characteristics and resistance to environmental effects in addition to friction measurements. The method used for the test surfaces consisted of: (1) a visual inspection of the bonding characteristics of the overlay materials during construction and at intervals following construction, (2) freeze-thaw tests, and (3) a visual inspection of the performance characteristics under actual weather conditions. The evaluations and supporting data obtained in the above described areas are as follows.

a. Bonding

The asphalt slurry overlays displayed excellent bonding characteristics on the concrete and asphalt surfaces at the time of construction. Under simulated traffic conditions, the slurry overlays on asphalt tended to break loose. The Palmer Pavetread overlays demonstrated good bonding characteristics on concrete (but demonstrated problems where they apparently reacted chemically with the joint-sealer), and the bonding on asphalt was considered ineffective due to the thinner softening the existing asphalt surface. This ineffective bonding permits water to get between the overlay and pavement surface which will continue to reduce the level of bonding between the two materials. The porous asphalt hot mix (with latex rubber) displayed excellent bonding characteristics on concrete and asphalt during construction and during the 6-month period following construction. The porous cold mix has disclosed a deficiency in bonding on concrete and asphalt surfaces which has resulted in an unacceptable level of raveling. The bond between the overlay and the concrete pavement appears to be deteriorating at a rate greater than on the asphalt pavement.

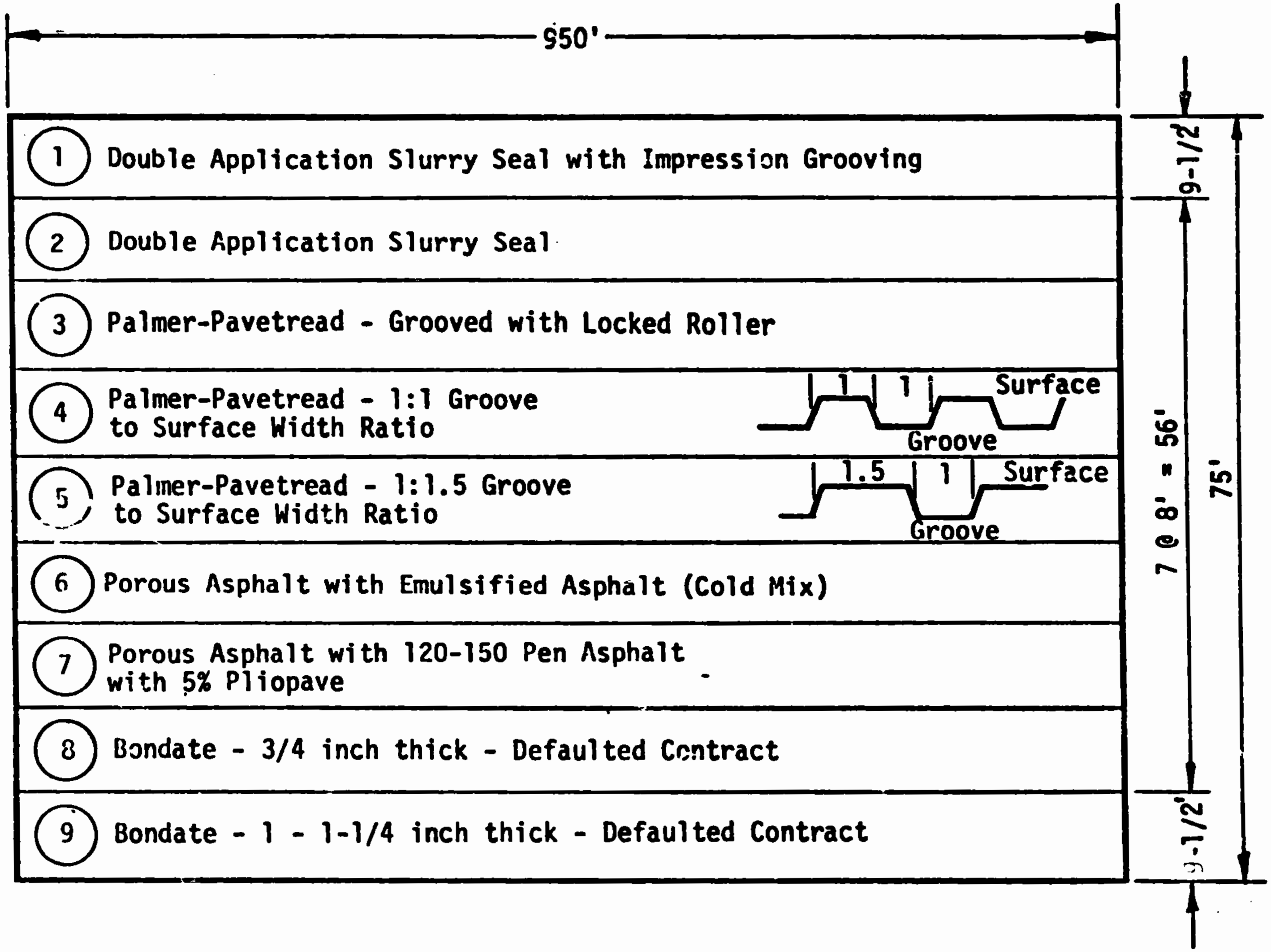


Figure 7. Location of Friction Textured Test Strips on Asphalt (Friction Test Area No. 2)

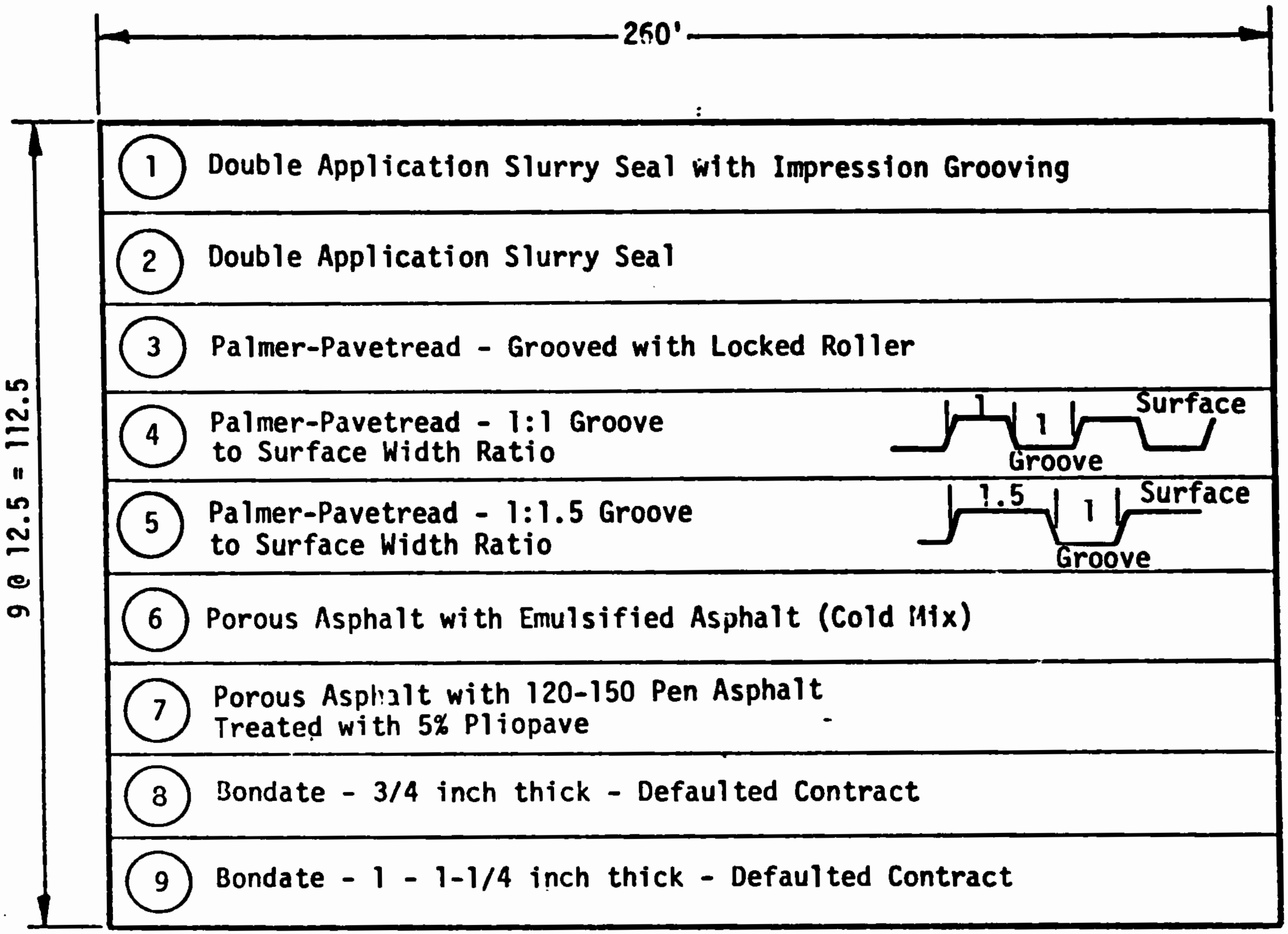


Figure 8. Location of Friction Textured Test Strips on Concrete (Friction Test Area No. 3)

b. Freeze-Thaw Tests

Small dikes or dams were constructed on the test surfaces within test areas 2 and 3 for a field evaluation of the resistance of the overlays to cycles of freezing and thawing. The freeze-thaw test areas as shown in figure 9 were filled with water during the afternoons of cold days to simulate actual freeze-thaw conditions. The test areas were subjected to 19 cycles of freezing and thawing between 4 February and 6 March 1974. The dates that the ponding areas were filled with water (freeze-thaw cycles) and the minimum daily temperatures are reported in table 8.

There is no evidence of any significant freeze-thaw deterioration in the asphalt slurry or the porous asphalt including latex rubber, but there is evidence of a deterioration in the bond in the porous asphalt cold mix as well as some damage in the Palmer Pavetread overlay at cracks.

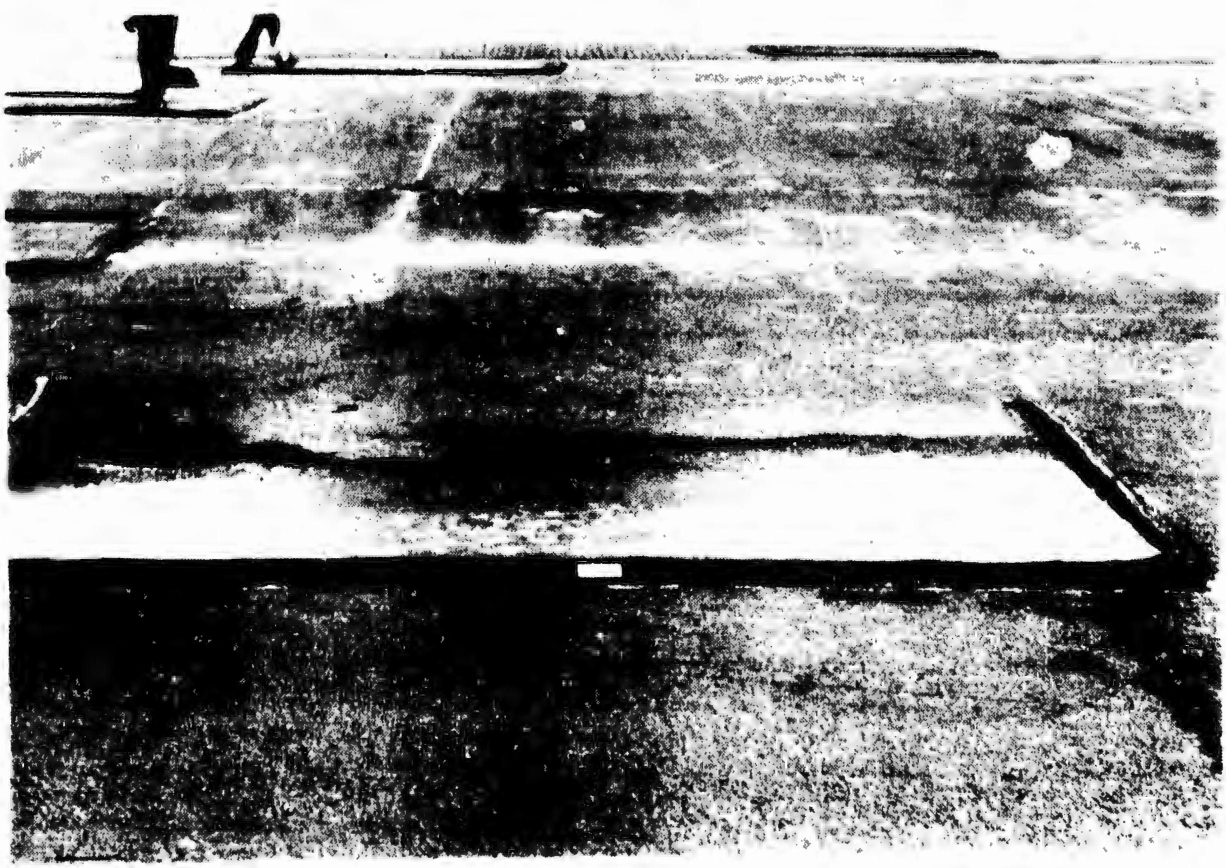


Figure 9. Freeze-Thaw Test Areas

Table 8

CYCLES OF FREEZING AND THAWING ON ANTIHYDROPLANING SURFACES (TEST AREAS 2 AND 3)

Date	Minimum Daily Temperature* (°F)	Accumulative Cycles of Freeze-Thaw
2-4-74	17	1
2-5-74	24	2
2-6-74	15	3
2-7-74	20	4
2-8-74	10	5
2-11-74	17	6
2-12-74	28	7
2-15-74	29	8
2-18-74	28	9
2-19-74	20	10
2-20-74	25	11
2-21-74	17	12
2-22-74	19	13
2-25-74	19	14
2-26-74	17	15
2-27-74	25	16
2-28-74	28	17
3-5-74	22	18
3-6-74	24	19

*From Local Climatological Data, US Department of Commerce

FIELD PERFORMANCE UNDER ACTUAL WEATHER CONDITIONS

An evaluation of the performance characteristics of the overlays under actual weather conditions is considered a valid study approach in view of the arid climate and significant variations in daily temperature in Albuquerque. Figures 10, 11, and 12 show maximum and minimum daily temperatures (as obtained from Local Climatological Data) for September, October, and November 1973.

The porous asphalt hot mix has demonstrated good performance under the existing weather conditions. The porous asphalt cold mix and the asphalt slurry are showing signs of raveling on concrete and asphalt; and there are signs of progressive deterioration in the bond between the Pavetread overlay and the asphalt surface.

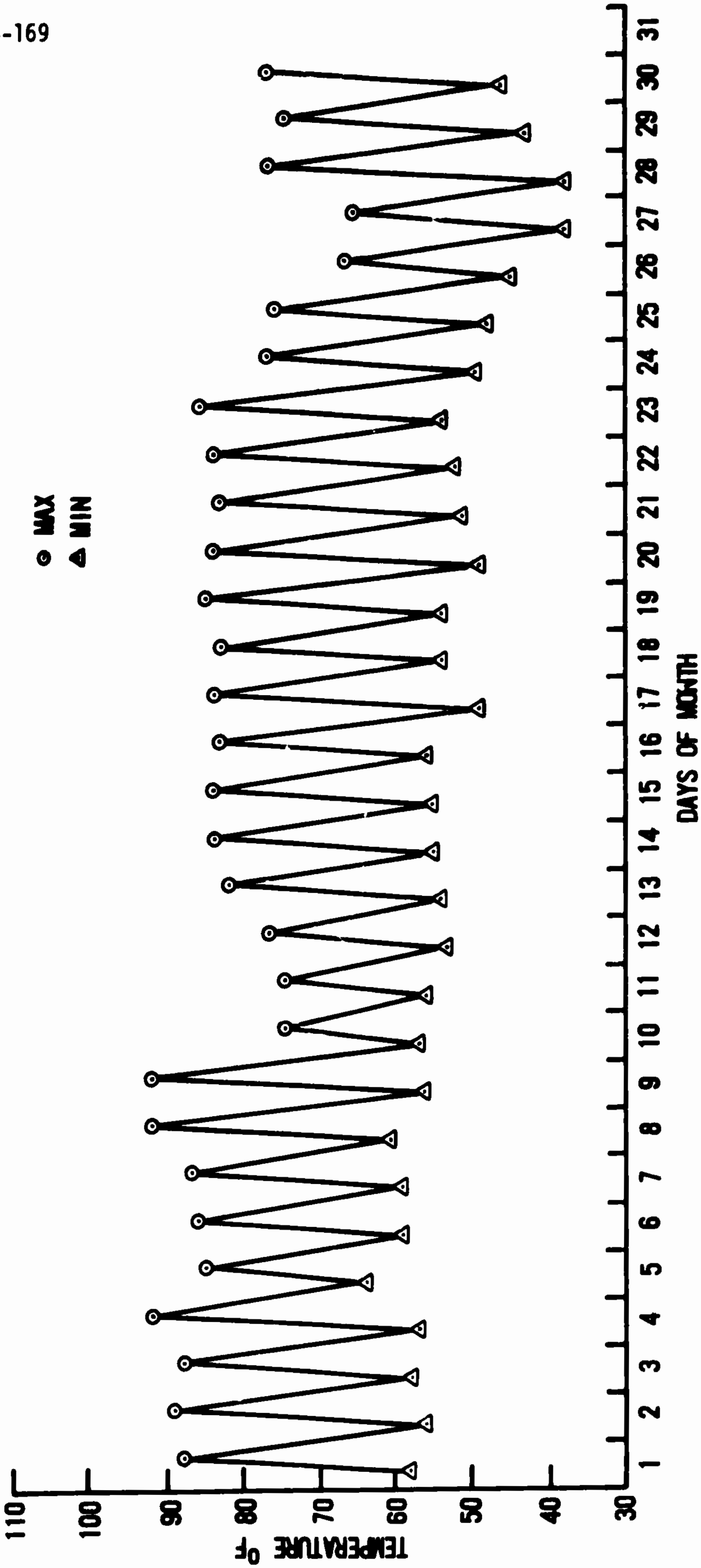


Figure 10. Maximum and Minimum Temperatures for September 1973

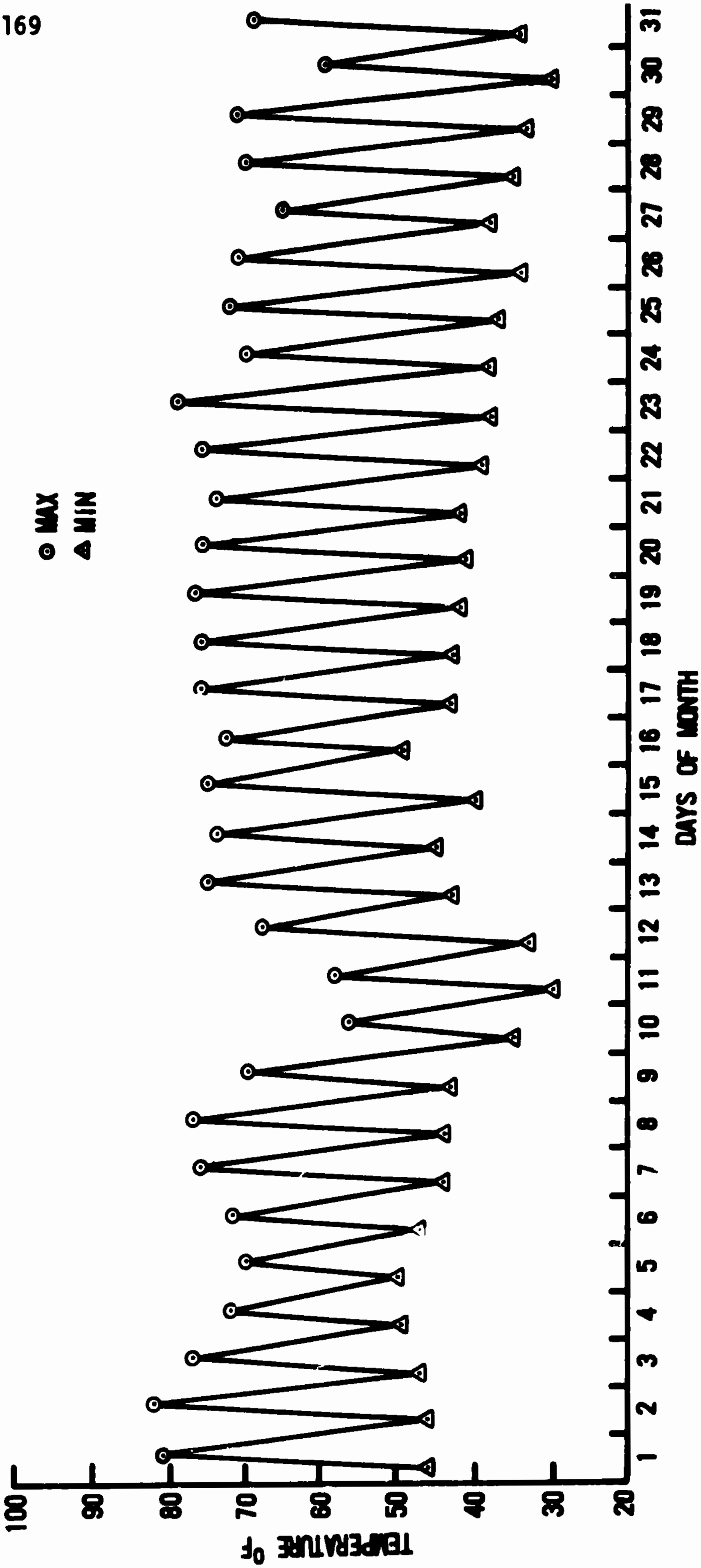


Figure 11. Maximum and Minimum Temperatures for October 1973

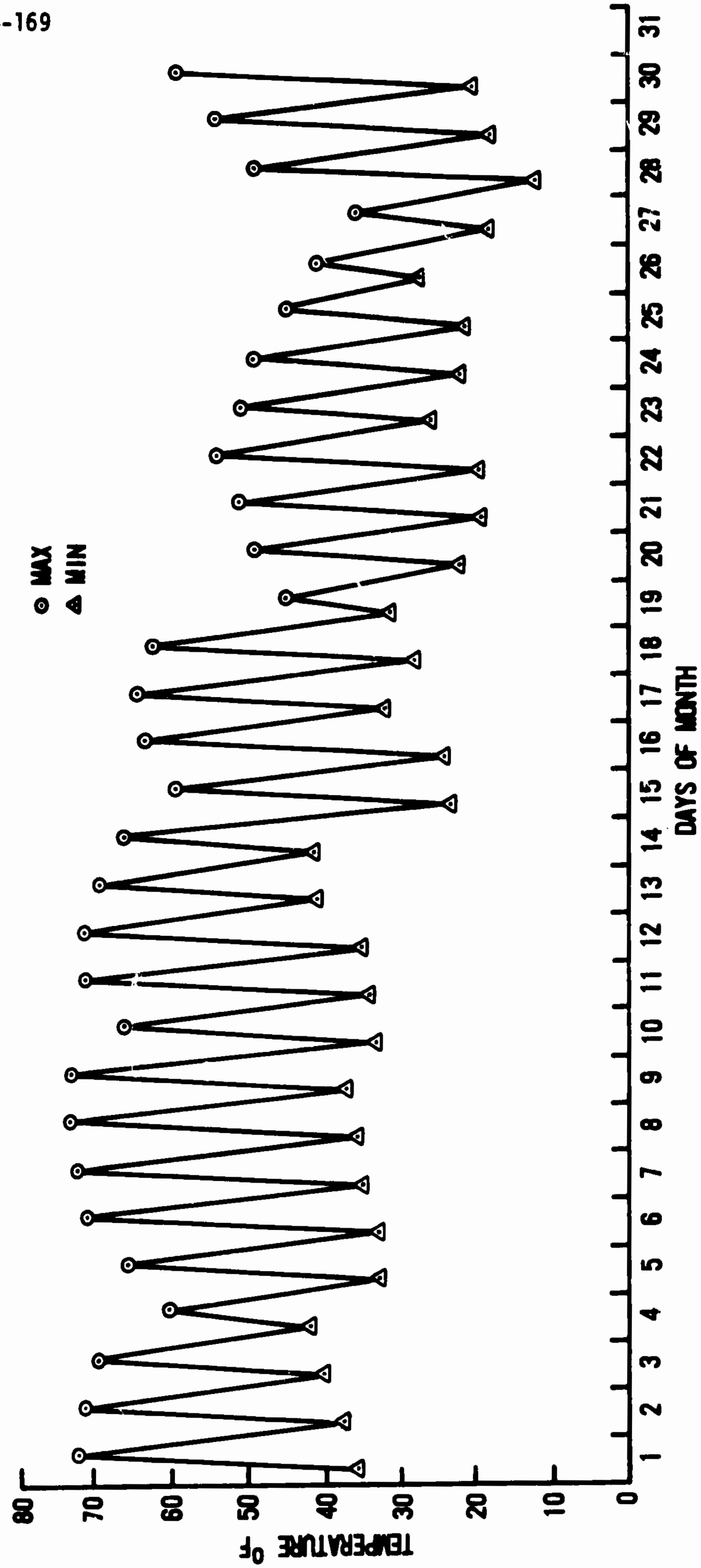


Figure 12. Maximum and Minimum Temperatures for November 1973

SECTION V

RESISTANCE OF POROUS ASPHALT AND ANTIHYDROPLANING SURFACES TO SIMULATED AIRCRAFT-WHEEL LOADINGS

A program of traffic testing was selected for the evaluation of the resistance of porous asphalt and antihydroplaning surfaces to simulated aircraft-wheel loadings during cold and hot weather. Figure 13 shows the four test loops located within test areas 1 and 2 and the original schedule for traffic testing. The method selected for the evaluation of the effects of traffic testing consisted of visual inspections, photographic documentation, and the monitoring of the change in the elevation of control points within the test strips.

Each test loop was to be subjected to (1) 500 passes with a single C-130 tire with 150 to 250-psi tire pressure and supporting a 20 to 40 kip load, and (2) 1000 passes with an F-4 tire with 200 to 300-psi tire pressure and supporting a 20 to 40 kip load. The figure-eight test loops as shown in figure 13 were painted on the surface with a broken white line (approximately 2-1/2 inches wide) to define the wheel path for traffic testing. Points for vertical control were established by painting a small circle and crossmarks at the intersections of the test strip centerlines and the figure-eight traffic pattern.

Due to funding and time limitations, the testing that was accomplished was restricted to the phase of testing scheduled for cold weather (see test loops 2 and 4 in figure 13). The program of traffic testing was started on test loop No. 4 to avoid interruptions during the first phase of testing by taxiing aircraft. The test operations and data obtained from the traffic testing of test loops 4 and 2 are described as follows.

1. TEST LOOP NO. 4

Photographs and elevations of the control points were obtained prior to traffic testing. The first series of load applications consisted of 500 passes with the C-130 tire with 100-psi tire pressure and a 25.5-kip load. The second series of load applications consisted of 500 passes with the F-4 tire with 285-psi tire pressure and a 30-kip load. Figure 14 shows the Pavetread test surface after 500 load applications with the C-130 tire and 500 load applications with the F-4 tire. The significant effects of the traffic testing are described as follows.

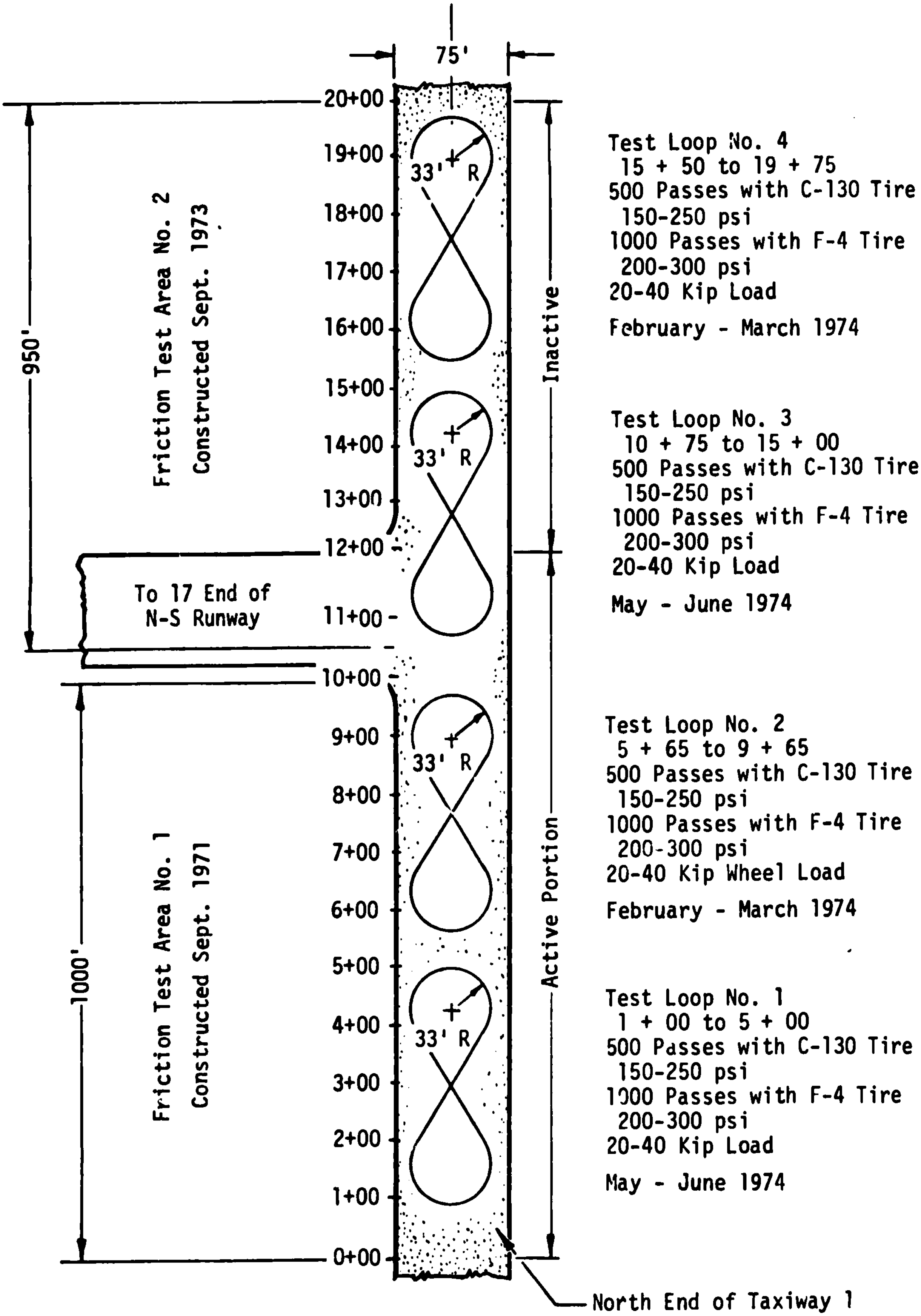


Figure 13. Location of Test Loops

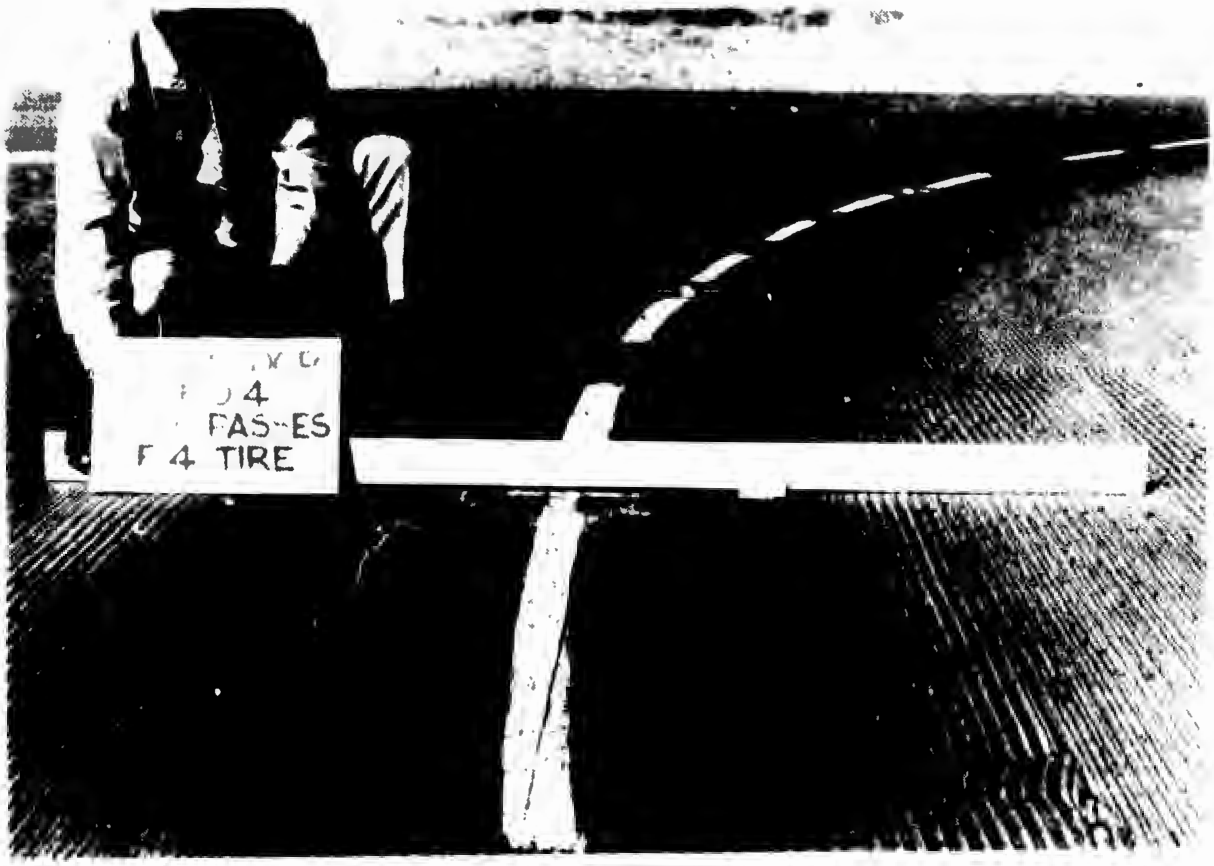


Figure 14. Pavetread After 500 Passes with C-130 and 500 Passes with F-4.

a. Five hundred passes with the C-130 tire caused excessive raveling of the porous asphalt cold mix and raveling of the asphalt slurry. There were no signs of raveling or surface distress in the Pavetread or porous asphalt hot mix test strips as a result of the 500 passes with the C-130 wheel load. The elevations of the control points before and after traffic are reported in table 9.

b. Approximately 200 passes of the F-4 tire disclosed signs of rutting and cracking in the Pavetread overlay. The testing was terminated after applying 500 F-4 load applications due to consolidations and/or shear failure within the pavement structure. The elevations of the control points before and after testing with the F-4 tire are reported in table 9. Table 10 contains surface depressions as measured at the control points from a straightedge (see figure 14) after the C-130 and F-4 loadings. Additional photographs showing these surface

Table 9

ELEVATION OF CONTROL POINTS, TEST LOOP NO. 4

Control Points	Elevation	Elevation After C-130	Elevation After F-4
1	98.[illegible]	98.88	98.86
2	98.83	98.83	98.82
3	98.70	98.70	98.69
4	98.59	98.59	98.58
5	98.34	98.34	98.32
6	98.22	98.21	98.21
7	98.10	98.09	98.09
8	98.04	98.04	98.03
9	97.86	97.86	97.84
10	97.74	97.72	97.69
11	97.56	97.56	97.54
12	97.13	97.13	97.10
13	97.07	97.07	97.03
14	96.96	96.96	96.92
15	96.93	96.93	96.88
16	96.78	96.78	96.74
17	96.72	96.72	96.68
18	96.62	96.62	96.54
19	96.55	96.55	96.50
20	96.52	96.52	96.46
21	96.51	96.51	96.45
22	96.87	96.86	96.83
23	97.21	97.21	97.19
24	97.52	97.52	97.50
25	98.37	98.36	98.32
26	98.60	98.60	98.59
27	98.81	98.80	98.80
28	99.07	99.07	99.05
29	99.08	99.07	99.07
30	99.07	99.06	99.02
31	99.01	99.01	98.97

Table 10

SURFACE DEPRESSIONS AFTER C-130 AND F-4 LOADINGS, TEST LOOP NO. 4

Points	Locations	Depressions (in.)
1	Test Strip No. 5 - Pavetread S. End of Loop	1/8
2	Test Strip No. 4 - Pavetread S. End of Loop	1/8
3	Test Strip No. 3 - Pavetread S. End of Loop	3/32
4	Test Strip No. 2 - Asphalt Slurry S. End of Loop	1/4 - photo
5	Test Strip No. 1 - Asphalt Slurry S. End of Loop	1/4
6	Test Strip No. 2 - Asphalt Slurry S. End of Loop	5/16
7	Test Strip No. 3 - Pavetread S. End of Loop	1/8
8	Test Strip No. 4 - Pavetread S. End of Loop	1/8
9	Test Strip No. 5 - Pavetread Center of Loop	3/8 - photo
10	Test Strip No. 6 - P.A. Cold Mix N. End of Loop	5/8 - photo
11	Test Strip No. 7 - P.A. Hot Mix N. End of Loop	1/8 - photo
12	Test Strip No. 8 - Leveling Course	0
13	Test Strip No. 9 - Leveling Course	3/16
14	Test Strip No. 8 - Leveling Course	1/16
15	Test Strip No. 7 - P.A. Hot Mix	1/8
16	Test Strip No. 6 - P.A. Cold Mix	3/16
17	Test Strip No. 5 - Pavetread	1/8
18	Test Strip No. 4 - Pavetread	9/16
19	Test Strip No. 3 - Pavetread	3/16
20	Test Strip No. 2 - Asphalt Slurry	1/2
21	Test Strip No. 1 - Asphalt Slurry	1/4
22	Test Strip No. 2 - Asphalt Slurry	3/16
23	Test Strip No. 3 - Pavetread	3/16
24	Test Strip No. 4 - Pavetread	5/16
25	Test Strip No. 6 - P.A. Cold Mix	3/16
26	Test Strip No. 7 - P.A. Hot Mix	7/32
27	Test Strip No. 8 - Leveling Course	1/8
28	Test Strip No. 9 - Leveling Course	1/16
29	Test Strip No. 8 - Leveling Course	1/8
30	Test Strip No. 7 - P.A. Hot Mix	3/16
31	Test Strip No. 6 - P.A. Cold Mix	3/16

depressions are contained in figures 15 through 18. The surface depressions resulted from raveling during the C-130 loadings and consolidation and/or shear failures during the F-4 loadings. The primary cause for the surface depressions was the F-4 loadings. The raveling of the surface texture due to the F-4 load applications was nominal when compared with the raveling that resulted from the C-130 tire.

2. TEST LOOP NO. 2

Test loop No. 2 was located on the porous asphalt test strips constructed in 1971. Photographs and elevations of the control points were obtained before and after testing with the C-130 wheel loadings. The first series of load applications consisted of 500 passes with the C-130 tire with 100-psi tire pressure and a 25.5-kip load. The second series of loadings consisted of 500 passes with the F-4 tire with 285-psi tire pressure and a 30-kip load. The effects of the traffic testing are described as follows.

a. Five hundred passes with the C-130 tire caused some raveling in test strip No. 8. The remaining porous asphalt designs resisted the turning action of the C-130 tire without showing any signs of surface raveling.

b. The porous asphalt test strips failed to show any signs of foundation or surface failures as a result of 500 applications of the F-4 tire. There were no significant changes in the elevations of the control points due to 500 passes with the C-130 wheel load. Elevations following 500 passes with the F-4 wheel load were not determined due to funding limitations, but visual inspection showed no significant changes. Periodic measurements from a straightedge (as in figure 14) failed to show any surface depressions greater than 1/8 of an inch.

Figure 15. Asphalt Slurry After 500 Passes with C-130 and 500 Passes with F-4

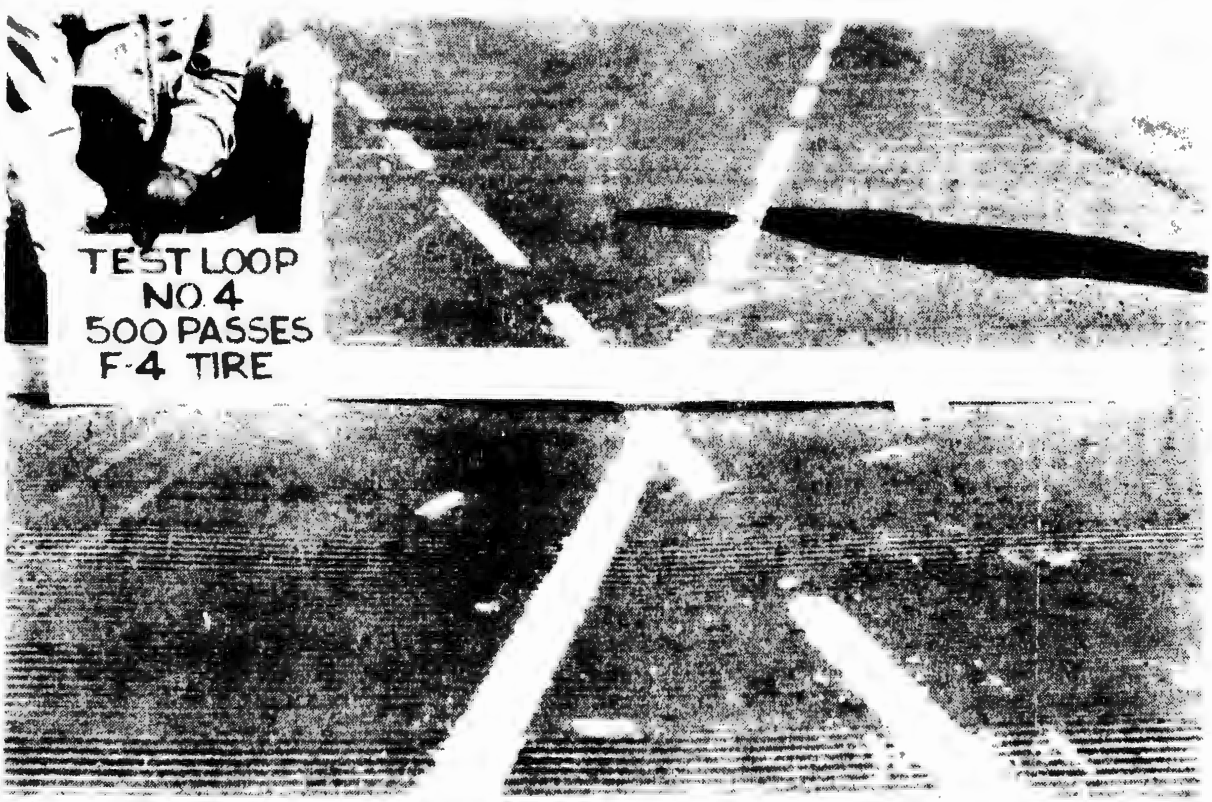


Figure 16. Pavetread After 500 Passes with C-130 and 500 Passes with F-4

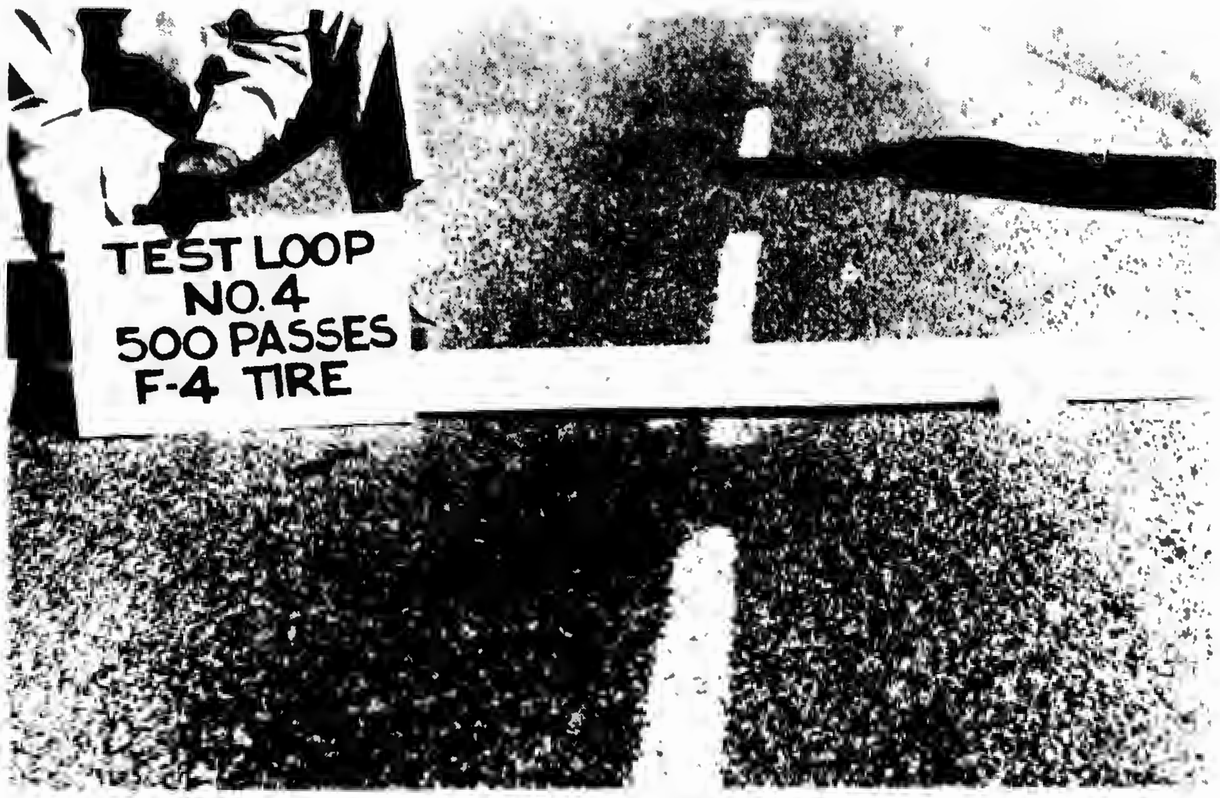


Figure 17. Porous Asphalt Cold Mix
After 500 Passes with C-130 and 500 Passes with F-4

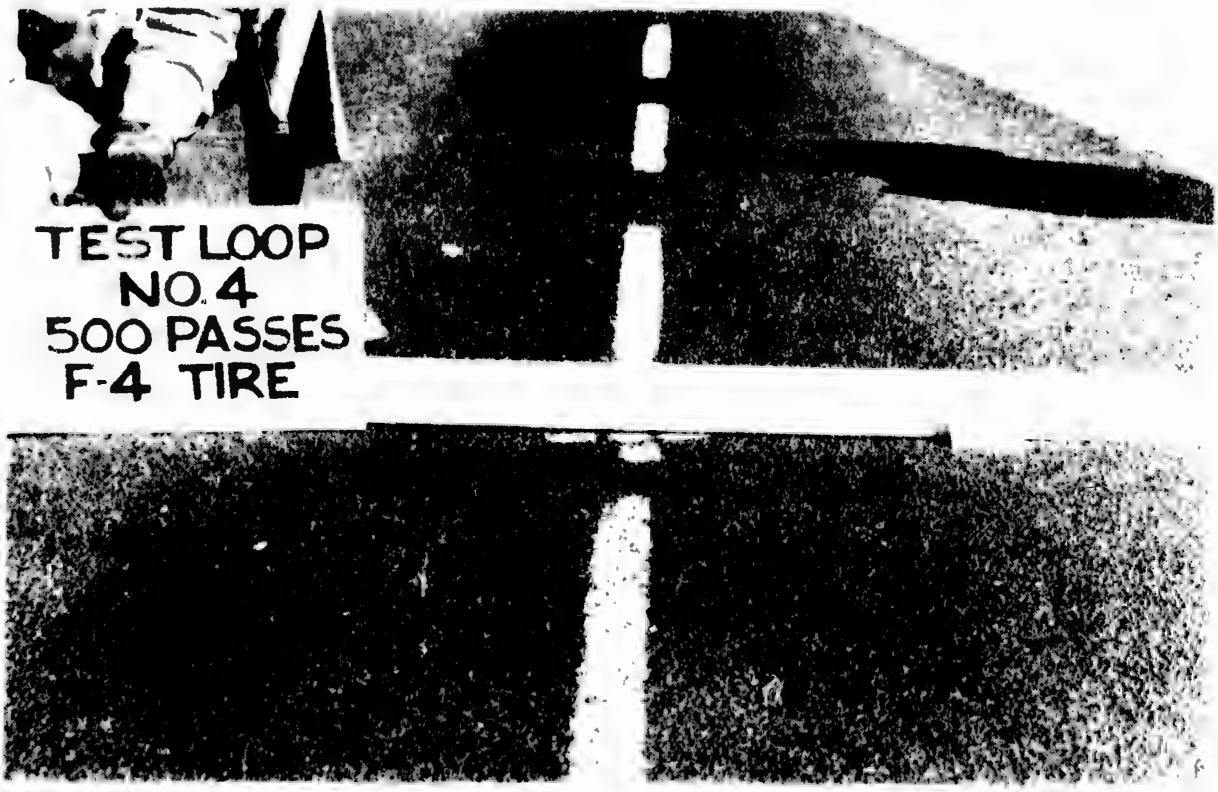


Figure 18. Porous Asphalt with Rubber
After 500 Passes with C-130 and 500 Passes with F-4

SECTION VI

SUMMARY AND CONCLUSIONS

This report on the short term performance of porous asphalt and antihydroplaning surfaces discloses limited, but significant, information regarding the resistance of the test surfaces to environmental effects, limited air traffic, and simulated aircraft wheel loadings. The scope of the field study is described as follows.

a. Monitoring resistance of porous asphalt test strips to environmental effects and the taxiing of aircraft over a 30-month period.

b. Laboratory investigation of the resistance of porous asphalt to freeze-thaw damage.

c. Monitoring the resistance of porous asphalt and antihydroplaning surfaces to environmental effects during a 6-month period.

d. Traffic testing porous asphalt and antihydroplaning test strips with simulated aircraft wheel loadings.

The primary conclusions derives from the above described test programs are summarized as follows.

a. All of the porous asphalt test strips within test area 1 have demonstrated good performance over a 30-month period under limited air traffic and existing weather conditions.

b. The cycles of freezing and thawing imposed on the porous asphalt test strips by the ponding areas failed to introduce any noticeable freeze-thaw damage.

c. The Marshall test specimens of porous asphalt suffered a loss in stability and an increase in diameter as a result of 50 cycles of freezing and thawing. The stability of the damp-freeze specimens was not affected markedly.

d. The following observations and conclusions were obtained from the monitoring of the porous asphalt and antihydroplaning test surfaces over a 6-month period.

(1) Excessive loss of aggregate due to traffic on the asphalt slurry.

(2) Good bonding action between the Pavetread and concrete, but an unacceptable reaction between the Pavetread and the asphaltic joint sealer.

(3) Unsatisfactory bonding of Pavetread to the asphalt pavement which is expected to undergo further deterioration due to cycles of freezing and thawing.

(4) Good performance from the porous asphalt prepared with rubber.

(5) Excessive loss of aggregate due to traffic on the porous surface with emulsified asphalt.

e. The effects of simulated aircraft wheel loadings on porous asphalt and antihydroplaning surfaces are described as follows.

(1) The subjection of the porous asphalt test strips to 500 passes with the C-130 tire resulted in an unacceptable level of raveling on test strip No. 8 (dual course construction). The remaining seven test strips displayed an acceptable level of resistance to the wheel loadings.

(2) The subjection of the porous asphalt test strips to 500 passes with the F-4 tire (in addition to the 500 passes with the C-130 tire) caused additional raveling of test strip No. 8 with no significant damage to the remaining seven test strips.

(3) The subjection of the porous asphalt and antihydroplaning surfaces to 500 passes with the C-130 tire introduced excessive raveling of the asphalt slurry and porous asphalt cold mix, but no damage to the Pavetread or porous asphalt hot mix prepared with latex rubber.

(4) The subjection of the porous asphalt and antihydroplaning surfaces to 500 passes with the F-4 tire (in addition to 500 passes with the C-130) caused additional raveling of the porous asphalt cold mix and cracking of the Pavetread. The cracking of the Pavetread was attributed to excessive consolidation and/or shear failures within the foundation layer.

(5) The porous asphalt hot mix (with latex rubber) resisted 500 passes with the C-130 tire and 500 passes with the F-4 tire without showing any signs of distress in the form of raveling or shoving. The performance of the overlay material under the simulated wheel loadings was considered superior to the asphalt slurry, porous asphalt cold mix, and Pavetread overlays.

APPENDIX

SPECIFICATIONS FOR POROUS ASPHALT OVERLAYS, TEST AREA NO. 1

1. TEST STRIP NO. 1 DUAL-COURSE OVERLAY CONSTRUCTION

a. Mix Design and Production

The dual-course overlay construction shall consist of a fine-grained cushion course (leveling course) consisting of a fine-grained asphalt paving strip with a coarse-graded plant mix seal rolled into the leveling course prior to compaction or hardening (while in a thermoplastic condition). The fine-grained cushion course shall be the same mix as specified for the overlay (waterproofing and leveling course) for the entire test area. The coarse graded surface course shall be placed on the fine-grained cushion course prior to the compaction or hardening of the cushion course so as to obtain partial embedment of the coarse aggregate in the thermoplastic cushion course. The aggregates are to be approved by the Contracting Officer and comply with the following gradation requirements.

Sieve Designation	Percent Passing
3/4 inch	100
1/2 inch	80-90
3/8 inch	40-55
No. 4	20-30
200	5-9

Hydrated lime, in the amount of 1.5 percent of the total job-mix formula, shall be used to furnish a part of the prescribed percentage of material passing the 200 sieve. For example, for a prescribed 5 percent passing 200, 1-1/2 percent shall be hydrated lime and the remaining 3-1/2 percent is to be a filler material as approved by the Contracting Officer. The material passing the No. 10 sieve may consist of crusher fines of clean sharp siliceous or igneous material. The coarse-graded mix is to be prepared by mixing 6 ±1 percent of 85-100 penetration asphalt with the coarse aggregates (No. 4 - 3/4 inch) for approximately 30 seconds then adding the filler material (passing 200) at normal air temperature. The coarse aggregates shall be heated to a temperature of 290 ±20°F for mixing.

b. Construction

Test strip No. 1 shall be constructed by placing the coarse-graded surface mix on the fine-grained cushion course (before compaction or hardening of the cushion course) and then rolling the dual-course overlay with a 5- to 8-ton steel wheel roller. The standby paver may be used to place the coarse-graded surface course following the placement of the fine-grained cushion course (leveling course). The fine-grained cushion course is to be applied at a temperature of 270 ±20°F, whereas the coarse-graded surface course is to be applied at a temperature of 260 ±20°F. The coarse-graded surface course is to be placed so as to yield a nominal uncompacted thickness of approximately 7/8 of an inch. The compacted total thickness of the dual-course overlay will be between 1-1/2 and 3-1/2 inches thick and comply with the lines and grades set forth in the plans.

2. TEST STRIP NO. 2 - NEW MEXICO PLANT MIX SEAL WITH 3/4-INCH TOPSIZE AGGREGATE

a. Design and Production

The porous surface course construction is to consist of an increase in the percentages of coarse aggregate up to a maximum aggregate size of 3/4 inch. The source of coarse aggregates (same for all eight test strips) is to be approved by the Contracting Officer as well as satisfying the following gradation requirements.

Sieve Designation	Percent Passing
3/4 inch	100
1/2 inch	85-95
3/8 inch	65-75
No. 4	30-50
No. 10	0-20
No. 40	0-12
No. 200	0-6

The material passing the No. 10 sieve may consist of crusher fines of clean sharp siliceous or igneous material. Hydrated lime, in the amount of 1.5 percent is to be used to furnish a part of the prescribed percentage of material passing the 200 sieve. For example, for a prescribed 6 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 4-1/2 percent is to be a filler material approved by the Contracting Officer.

The mix is to be prepared by mixing the heated aggregates and asphalt for approximately 30 seconds and then adding the filler material (passing 200) at normal air temperature. After adding the filler material the asphalt binder is to consist of 10 ±5 percent of 85-100 pen asphalt heated to a temperature not to exceed 260°F for mixing. The aggregates (less filler) are to be heated to a temperature not to exceed 260°F for mixing. The filler material is added at normal air temperature to stiffen the mixture and prevent segregation of the asphalt binder during transportation and placement.

b. Construction

Test strip No. 2 shall be constructed by placing the coarse-graded surface mix on the compacted fine grain leveling course. A tack coat shall be applied prior to construction of the surface course. The surface course material is to be placed with a conventional paver so as to yield a nominal compacted thickness of 3/4 of an inch. The surface course material shall be placed at a temperature not less than 180°F and initially compacted following placement with a steel wheel roller weighing 5 to 8 tons. Immediately following this initial rolling, the entire surface of Test Strip 2 will be continuously rolled with self-propelled pneumatic-tired rollers as directed by the Contracting Officer. The combined thickness of the fine-grained leveling course and the surface course will be between 1-1/2 and 3-1/2 inches and comply to the lines and grades set forth in the plans.

3. TEST STRIP NO. 3 - BRITISH SPECIFICATIONS FOR AGGREGATE WITH 60-70 PENETRATION ASPHALT

a. Mix Design and Production

The porous overlay material for test strip No. 3 is to consist of 60-70 penetration asphalt and an aggregate structure graded in accordance with British Specifications for a porous asphalt friction course. The aggregates shall comply with the following gradation requirements.

Sieve Designation	Percent Passing
1/2 inch	100
3/8 inch	90-100
1/4 inch	40-56
1/8 inch	22-28
200	3-5

Hydrated lime, in the amount of 1.5 percent, is to be used to furnish a part of the prescribed percentage of material passing the 200 sieve. For example, for the prescribed 3 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 1-1/2 percent may be crusher dust of siliceous or igneous material approved by the Contracting Officer.

The asphalt binder is to consist of 6 ±1 percent of 60-70 penetration asphalt heated to a temperature of 240 ±35°F (or as directed by the Contracting Officer) for mixing. The aggregates are to be heated to a temperature of 212 ±36°F (or as directed by the Contracting Officer) for mixing. At the time of mixing the temperature of the aggregates and binder shall be within 28°F of each other. The mixing of the aggregates and asphalt shall be continued for a period of at least 1-1/2 minutes. Overheating of aggregates or binder shall be prohibited and reheating of condemned mixtures because of overheating shall be prohibited.

b. Construction

The porous friction course shall be placed on the compacted fine-grained leveling course with a conventional paving machine. The surface of the leveling course shall receive a tack coat prior to construction of surface course. The surface course is to be placed at a temperature not less than 167°F to yield a nominal compacted thickness of 3/4 inch. Following placement the surface course is to be compacted at a temperature not less than 158°F with a steel wheel roller weighing 5 to 8 tons. The compacted thickness of the leveling course and the porous surface course will be between 1-1/2 and 3-1/2 inches thick and comply to the lines and grades specified on the contract drawings.

4. TEST STRIP NO. 4 - BRITISH POROUS FRICTION OVERLAY

a. Mix Design and Production

The surface course for test strip No. 4 is the British specification for porous friction asphalt construction. The aggregates are to be approved by the Contracting Officer and comply with the following gradation requirements.

Sieve Designation	Percent Passing
1/2 inch	100
3/8 inch	90-100
1/4 inch	40-56
1/8 inch	22-28
200	3-5

Hydrated lime in the amount of 1.5 percent is to be used to furnish a part of specified percentage of material passing the 200 sieve. For example, for a specified 3 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 1-1/2 percent may be crusher dust of siliceous or igneous material approved by the Contracting Officer.

The asphalt binder is to consist of 6 ±1 percent of 200-300 pen asphalt heated to a temperature of 240 ±35°F. The aggregates are to be heated to a temperature of 212 ±36°F. At the time of mixing the temperature of the aggregates and binder shall be within 28°F of each other. Overheating of aggregates or binder shall be prohibited and reheating of condemned mixtures because of overheating shall likewise be prohibited. The heated aggregates and asphalt are to be mixed for at least 1-1/2 minutes and until thoroughly mixed.

b. Construction

The surface course shall be placed on the compacted fine-grained leveling course in a manner similar to construction procedure required for test strip No. 3. A tack coat shall be placed on the leveling course prior to constructing the surface course. The surface course shall be applied with a conventional paving machine so as to yield a nominal compacted thickness of 3/4 of an inch. The temperature of the porous asphalt mix shall not be less than 167°F at the time of placement. The temperature of the surface course prior to compaction shall not be less than 158°F. Compaction shall be obtained with a steel wheel roller weighing 5 to 8 tons.

5. TEST STRIP NO. 5 - BRITISH SPECIFICATIONS MODIFIED TO INCLUDE 3/4-INCH TOPSIZE AGGREGATE AND 120-150 PENETRATION ASPHALT

a. Mix Design and Production

The porous overlay material for test strip No. 5 is a modification of the British specifications (test strip 4) so as to include 3/4-inch topsize aggregate and 120-150 penetration asphalt in the mix. The aggregates are to be approved by the Contracting Officer and comply with the following gradation requirements.

Sieve Designation	Percent Passing
3/4 inch	100
1/2 inch	85-95
3/8 inch	40-56
No. 4	22-28
200	3-5

Hydrated lime, in the amount of 1.5 percent, is to be used to furnish a part of the specified percentage of material passing the 200 sieve. For example, for a specified 3 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 1-1/2 percent may be crusher dust of siliceous or igneous material approved by the Contracting Officer.

The mix is to be prepared by mixing the aggregates, heated to a temperature of 212 ±36°F (or as directed by the Contracting Officer), with 6 ±1 percent of 120-150 penetration asphalt heated to a temperature of 240 ±35°F (or as directed by the Contracting Officer). Overheating of aggregates or binder shall be prohibited and reheating of condemned mixtures because of overheating shall likewise be prohibited. The heated aggregates and asphalt are to be mixed for at least 1-1/2 minutes and until thoroughly mixed.

b. Construction

The porous friction course shall be placed on the compacted fine-grained leveling course with a conventional paving machine in a similar manner as test strip 4. A tack coat shall be placed on the leveling course prior to constructing the surface course. The surface course is to be applied at a temperature of not less than 167°F to yield a nominal compacted thickness of 3/4 of an inch.

Following placement, the surface course is to be compacted at a temperature not less than 158°F with a steel wheel roller weighing 5 to 8 tons. The compacted thickness of the cushion course and the porous surface course will be between 1-1/2 and 3-1/2 inches thick and comply with the lines and grades specified on the plans.

6. TEST STRIP NO. 6 - BRITISH SPECIFICATIONS FOR AGGREGATE WITH 120-150 PENETRATION ASPHALT

a. Mix Design and Preparation

The porous overlay material for test strip No. 6 is to be in accordance with the British specifications (test strip 4) for aggregate structure with 120-150 penetration asphalt. The aggregates are to be approved by the Contracting Officer and comply with the following gradation requirements.

Sieve Designation	Percent Passing
1/2 inch	100
3/8 inch	90-100
1/4 inch	40-56
1/8 inch	22-28
200	3-5

Hydrated lime, in the amount of 1.5 percent, is to be used to furnish as part of the specified percentage of material passing the 200 sieve. For example, for the specified 3 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 1-1/2 percent may be crusher dust of siliceous or igneous material approved by the Contracting Officer.

The mix is to be prepared by mixing the aggregates, heated to a temperature of 212 ±36°F (or as directed by the Contracting Officer), with 6 ±1 percent of 120-150 penetration asphalt heated to a temperature of 240 ±35°F (or as directed by the Contracting Officer). At the time of mixing the temperature of aggregates and binder shall be within 28°F of each other. Overheating of the aggregates or binder shall be prohibited and reheating of condemned mixtures because of overheating shall likewise be prohibited. The heated aggregates and asphalt are to be mixed at least 1-1/2 minutes and until thoroughly mixed.

b. Construction

The porous friction course shall be placed on the compacted fine-grained leveling course with a conventional paving machine in a similar manner as test strip 4. A tack coat shall be placed on the leveling course prior to constructing the surface course. The surface course is to be applied at a temperature not less than 167°F to yield a nominal compacted thickness of 3/4 of an inch. Following placement, the surface course is to be compacted at a temperature not less than 158°F with a steel wheel roller weighing 5 to 8 tons. The compacted thickness of the cushion course and the porous surface course will be between 1-1/2 and 3-1/2 inches thick and satisfy the lines and grades specified on the plans.

7. TEST STRIP NO. 7 - MARSHALL DESIGN

a. Mix Design and Preparation

The overlay material for test strip No. 7 will be in accordance with the Marshall design procedure currently used by the Air Force for the design of asphaltic surface courses for airfield pavements. The asphalt cement shall conform to Federal Specifications SS-A-706, AP-5 (penetration of 60-70). The aggregate is to be graded in accordance with the following requirements.

Sieve Designation	Percent Passing
3/4 inch	100
1/2 inch	82-100
3/8 inch	75-90
No. 4	60-73
No. 10	43-57
No. 20	29-43
No. 40	19-33
No. 200	3-6

Hydrated lime, in the amount of 1.5 percent, is to be used to furnish a part of the specified percentage of material passing the 200 sieve. For example, for a specified 3 percent passing 200, 1-1/2 percent is to be hydrated lime and the remaining 1-1/2 percent may be crusher dust of siliceous of igneous material approved by the Contracting Officer.

The asphalt binder shall consist of 6 ±1 percent of 60-70 penetration asphalt heated to a temperature of 285 ±35°F for mixing. The aggregates shall be heated to a temperature not exceeding 350°F at the time of mixing nor more than 25°F greater than temperature of asphalt at the time of mixing.

The job-mix formula shall be so designed that the maximum asphalt content is used consistent with the following requirements.

Stability (Marshall)	1800 pounds plus
Flow (Marshall)	16 or less
Percent voids	2-4
Percent voids fill with asphalt	70-80

For the purpose of calculating the percentage of voids for the total mix and voids filled with asphalt, the specific gravities of the various aggregates shall be selected as follows: when the absorption of the aggregate as determined by the applicable ASTM Standard C 128 or C 127 is 1 percent or greater, the mean between the bulk and the apparent specific gravities shall be used.

b. Construction

The Marshall designed surface course shall be placed on the compacted fine-grained leveling course with a conventional paving machine. A tack coat shall be placed on the leveling course prior to constructing the surface course. The surface course is to be placed at a temperature of not less than 225°F to yield a nominal compacted thickness of 3/4 of an inch. Following placement, the surface is to be initially compacted with a steel wheel roller weighing 5 to 8 tons. Immediately following rolling with steel wheel roller, the entire surface to test strip 7 shall be continuously rolled with a self-propelled pneumatic tired roller as directed by the Contracting Officer. If proper compaction is not obtained a heavier steel wheeled roller may be required as directed by the Contracting Officer. The compacted thickness of the cushion course and the Marshall surface course will be between 1-1/2 and 3-1/2 inches thick and comply with the lines and grades specified on the plans.

8. TEST STRIP NO. 8 - DUAL-COURSE OVERLAY CONSTRUCTION

a. Mix Design and Preparation

The dual-course overlay construction is to consist of a fine-grained cushion course (leveling course) consisting of a fine-grained asphalt paving mix with a coarse-graded plant mix seal rolled into the leveling course prior to compaction or hardening (while in a thermoplastic condition). The fine-grained course shall be the same mix as specified for the leveling and waterproofing of the entire test section. The coarse-graded surface course shall consist of 90 percent of aggregate graded between 1/2 and 3/4 inch and a matrix of asphalt cement and material passing the No. 10 sieve. The aggregates shall be approved by the Contracting Officer and satisfy the following gradation requirements.

Sieve Designation	Percent Passing
3/4 inch	100
1/2 inch	10
No. 10	3-7
No. 200	1.5-3

Hydrated lime, in the amount of 1.5 percent, shall be used to furnish a part of the specified percentage of material passing the 200 sieve. For example, for a specified 3 percent passing 200, 1-1/2 percent may be crusher dust of siliceous or igneous material approved by the Contracting Officer. The coarse-graded mix is to be prepared by mixing 5 ±1 percent of 60-70 penetration asphalt with the coarse aggregate (1/2 to 3/4 inch) for approximately 30 seconds then adding the fines and filler material (passing No. 10) at normal air temperature. After adding the filler material the mixing operation is to be continued for approximately 20 seconds. The coarse aggregate shall be heated to a temperature of 290 ±15°F and the asphalt cement shall be heated to a temperature of 280 ±15°F for mixing.

b. Construction

This strip shall be constructed by placing the coarse-graded surface mix on the fine-grained cushion course (before compaction or hardening of the cushion course) and then rolling the dual-course overlay with a steel wheel roller weighing 5 to 8 tons. The standby paver may be used to place the coarse-graded surface course following the placement of the fine-grained cushion course (leveling course). The fine-grained cushion course shall be applied at a temperature of 270 ±20°F, and the coarse-graded surface course shall be applied at a temperature of 260 ± 20°F. The coarse-graded surface course shall be placed so as to yield a nominal uncompacted thickness of approximately 7/8 of an inch. The compacted total thickness of the dual-course overlay will be between 1-1/2 and 3-1/2 inches thick and comply with the lines and grades shown on contract drawings.

REFERENCES

1. Hargett, Emil R., An Analysis of Airfield Pavement Traction, AFWL Technical Note, Air Force Weapons Laboratory, Kirtland Air Force Base, NM, 1972.

2. Hargett, Emil R., Evaluation of Construction Techniques for New Antihydroplaning Overlays, AFWL-TR-74-77, Air Force Weapons Laboratory, Kirtland Air Force Base, NM, June 1974.

3. Hargett, Emil R., Letter report, "Loss in Unconfined Compressive Strength of Porous Asphalt Due to Freeze-Thaw Damage," to Air Force Weapons Laboratory, Kirtland Air Force Base, NM, July 1971.