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TECHNICAL MEMORANDUM

title: AIRFIELD PAVEMENT CONDITION SURVEY, (USNAS) (MOFFETT) (FIELD), CALIFORNIA, by

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CIVIL ENGINEERING LABORATORY

NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

AIRFIELD PAVEMENT CONDITION SURVEY, USNAS MOFFETT FIELD, CALIFORNIA

Technical Memorandum M-75-53-1

53-024

by

R. B. Brownie and L. J. Wołoszynski

ABSTRACT

The results of a condition survey and friction measurements on the runways at the U.S. Naval Air Station, Moffett Field, California are presented. The survey established statistically-based condition numbers (weighted defect densities) which were direct indicators of the condition of the individual pavement facilities. The runway friction measurements showed the aircraft hydroplaning/skidding potential of the field. The results of the condition survey show an increase in the amount of pattern cracking on Runway 14R-32L and a slight decrease in the amount of defective joint seal on Runway 14L-32R. Runway friction measurements show Runway 14R-32L has very high probability for most aircraft to hydroplane and Runway 14L-32R has the potential to cause hydroplaning of some aircraft.

TABLE OF CONTENTS

	Page
INTRODUCTION.	1
BACKGROUND.	1
CONSTRUCTION HISTORY.	1
CURRENT AIR TRAFFIC	2
CLIMATOLOGICAL DATA	2
PAVEMENT CONDITION SURVEY	2
Condition Survey Procedure.	2
Results of Condition Survey	2
RUNWAY FRICTION MEASUREMENTS.	2
Test Locations.	3
Test Equipment.	3
Test Procedures	3
Runway Friction Test Results.	4
DISCUSSION OF RESULTS	5
Condition Survey Results.	5
Runway Friction Measurements.	5
RECOMMENDATIONS FOR FURTHER EVALUATION EFFORT	6
REFERENCES.	6
Table 1. Aircraft Operations Data.	7
Table 2. Types of Aircraft Using USNAS Moffett Field, California	8
Table 3. Defect Severity Weights	9
Table 4. Runway Friction Measurement Summary	10
Table 5. Mu-Meter Aircraft Pavement Rating	11
Table 6. Runway Pavement Slopes.	12
Figure 1. Aerial View of USNAS Moffett Field, California	13
Figure 2. Discrete Area Map.	14
Figure 3. Pattern Cracking Discrete Area R14R-1.	15
Figure 4. Epoxy Concrete Spall Repair in Good Condition, Discrete Area R14L-1.	16
Figure 5. Shrinkage Cracking, Discrete Area R14L-3	17
Figure 6. Friction Test Locations.	18
Figures 7-10 Friction Coefficient Versus Distance.	19-22
Figures 11-14 Average Friction Coefficient Versus Time After Wetting.	23-26
Discrete Area Summaries	27
Facility Defect Summaries	35
Discrete Area Condition Analysis.	39
Appendix A. Construction History	47
Appendix B. Climatological Data.	57
Appendix C. Condition Survey Procedures.	61
Appendix D. Mu-Meter Test Results.	75

INTRODUCTION

In October 1969, The Naval Facilities Engineering Command authorized a series of periodic pavement condition surveys to be conducted at Naval and Marine Corps Air Stations. The purpose of these condition surveys was to determine the suitability of the airfield pavement surfaces for aircraft operations, and to establish a uniform basis for maintenance and repair efforts. A pavement condition survey was conducted at the Naval Air Station, Moffett Field, California by the Naval Civil Engineering Laboratory* in March 1970 and reported in reference (1). Commencing in FY-75, pavement condition surveys will be performed only on active runways and increased emphasis will be placed on determining runway friction coefficients. During the month of April 1975, a second pavement condition survey and runway friction measurements were made at NAS Moffett Field by CEL. The survey consisted of a sophisticated, statistically-based procedure of pavement defect measurement which permitted the establishment of condition numbers (weighted defect densities) which are direct indicators of the condition of airfield pavement facilities. Runway friction measurements were made using a Mu-Meter, a small friction-measuring trailer. Additional survey efforts included photographic coverage of pavement defect types, preparation of a construction history of the airfield, compilation of current aircraft traffic data, summarization of climatological data, and delineation of requirements for future pavement evaluation efforts at the station.

BACKGROUND

The U.S. Naval Air Station, Moffett Field, is located in Santa Clara County, two miles from Mountain View, California, at an elevation of 40 feet. An aerial view of the station is shown in Figure 1. The airfield has two runways, 14R-32L and 14L-32R, which are 8,200 and 9,200 feet long respectively and lie parallel in a generally north-south direction.

CONSTRUCTION HISTORY

Construction of the air station began in 1938 when 2,410 feet of Runway 14R-32L and Hangar 1 were constructed. Subsequent extensions and overlays to Runway 14R-32L have been made to account for its present length of 8,200 feet. Runway 14L-32R was originally constructed in 1946 with a length of 7,425 feet. It was extended in 1951 and again in 1956 to its present length of 9,200 feet. A complete history of construction and recorded maintenance is provided in Appendix A.

* On 1 January 1974, redesignated the Civil Engineering Laboratory (CEL) of the Naval Construction Battalion Center, Port Hueneme, California

CURRENT AIRCRAFT TRAFFIC

A tabulation of the number of aircraft operations for a 12 month period is shown in Table 1. Table 2 lists the aircraft normally based at the station and transient aircraft observed using the station.

CLIMATOLOGICAL DATA

A summary of climatological data for NAS Moffett Field is presented in Appendix B.

PAVEMENT CONDITION SURVEY

Condition Survey Procedure

The condition survey procedure used at NAS Moffett Field was developed by CEL in 1968. This procedure permits the establishment of condition numbers (weighted defect densities) which are direct indicators of the pavement surface condition. A complete description of the pavement condition survey procedure is presented in Appendix C. It should be noted that Appendix C describes procedures for both asphaltic concrete (AC) and portland cement concrete (PCC) pavements, and includes other pavement facilities in addition to runways. At NAS Moffett Field only the runways were surveyed. Discrete areas were selected after a preliminary inspection of the runways. The locations of the discrete areas are shown in Figure 2. Defect severity weights as used at NAS Moffett Field are given in Table 3.

Results of Condition Survey

The results of the survey of each discrete area are shown in the Discrete Area Defect Summary sheets, pages 29 through 33 of this report. Each discrete Area Defect Summary includes a narrative description of the pavement defects encountered. In addition, photographs of typical pavement conditions noted during the survey can be seen in Figures 3 through 5. Facility Defect Summaries are shown on pages 37 and 38.

Total weighted defect densities range from 1.07C (00.00C being no visible defects) for discrete area R14L, to 3.40C for discrete area R14R-2. The only asphaltic concrete discrete area, R14R-1, has a defect density of 2.71A. An analysis of the change in pavement condition since the last condition survey is given in the Discrete Area Condition Analysis sheets, pages 41 through 45.

RUNWAY FRICTION MEASUREMENTS

The skid resistance/hydroplaning characteristics of the runway surfaces were evaluated with a Mu-Meter friction measuring device. The test program

consisted of field measurements of skid resistance/hydroplaning potential under standardized, artificially-wet conditions. In addition, both transverse and longitudinal pavement slopes were measured at intervals along each runway centerline to evaluate surface drainage characteristics.

Test Locations

Four test sections on each runway were selected to provide a representative sample of the skid resistance properties of each runway. The test section layout is shown in Figure 6. The test sections were selected to provide pavement friction data in: (a) the aircraft touchdown areas, and (b) the runway interior where maximum braking is normally developed.

Test Equipment

The principal items of test equipment used were the Mu-Meter, a tank truck for water application, and a device for measuring pavement slopes.

The Mu-Meter is a small trailer, designed and manufactured by M. L. Aviation of Maidenhead, England. It measures the side-force friction coefficient generated between the pavement surface and the pneumatic tires on the two wheels which are set at a fixed toe-out (yaw angle) to the line of drag. The Mu-Meter is a continuous recording device that graphically records the coefficient of friction, μ^* versus the distance traveled along the pavement.

The water truck provided by the station was a runway foamer with a spray nozzle and pumping system calibrated to place 0.1 inch of water on the skid test strip with each pass.

The slope measuring device consisted of a rectangular aluminum section (10 feet long, 1 inch thick, and 4 inches high) with machinists levels attached to define slope from 0 to 2.5 percent.

Test Procedures

The field test procedures utilized at NAS Moffett Field are those outlined in NAVFAC INSTRUCTION 1132.14B. The methods were:

(1) A preliminary reconnaissance of the pavement surfaces was made and representative test areas (each 1000 feet long) were selected for skid testing.

(2) Transverse and longitudinal slope measurements were made at 500 foot intervals along the runway centerline. Transverse measurements were

* The symbol μ or μ designates the coefficient of friction which is a constant used to represent the ratio of frictional force to force normal to the pavement surface.

made at two places on each side of the centerline covering a distance of approximately 20 feet. Longitudinal measurements were made on the centerline at the same stations where the transverse measurements were made.

(3) The water truck, which had been calibrated to apply 0.1 inch of water each time it passed over a test strip, made two passes over the test strip.

(4) Mu-Meter runs at 40 miles per hour, 1.2 times the theoretical hydroplaning speed for this vehicle, were initiated immediately after completion of the second water truck pass. Mu-Meter runs were made in alternate directions at convenient time intervals until a dry pavement condition was reached or 30 minutes had elapsed.

(5) All water truck and Mu-Meter operations were measured to the nearest second using a stop watch.

Runway Friction Test Results

The pavement skid resistance results are reported in terms of mu, coefficient of friction, as measured by the Mu-Meter. The actual friction coefficient versus distance traces as recorded by the Mu-Meter during the first run after wetting for each test section are shown in Figures 7 through 10. The traces show the variation of friction coefficient within each test section. Sharp dips in the curves indicate areas of lower friction values. At NAS Moffett Field the low-coefficient areas correspond to areas of localized ponded water. Appendix D contains all test results for each Mu-Meter test section.

Figures 11 through 14 show changes in surface friction coefficient versus time after wetting for each pavement section tested. (Note that the time intervals after wetting at which skid tests were made often differed from one test to another, due to small variations in water truck speed and Mu-Meter adjustments). These graphs demonstrate the natural drainage characteristics of the runway surface and the time required to return to an essentially dry condition or a consistently high friction coefficient.

A summary of test data and an associated Mu-Meter aircraft pavement rating guide are presented in Tables 4 and 5. The rating guide was developed from the results of an Air Force Weapons Laboratory research program and a joint NASA/AF/FAA test program using actual aircraft correlated with Mu-Meter skid coefficient results. While the current state-of-the-art does not allow a more precise delineation of exact aircraft responses, the rating guide provides a good rule-of-thumb for interpretation of test data.

Table 4 presents the average skid resistance values for each skid test section. From the curves presented in Figures 11 through 14, values of mu were determined for time periods of 3, 15, and 30 minutes

after water was applied. The coefficient determined at 3 minutes after water application corresponds to a wet runway condition and the coefficient determined at 15 minutes after water application corresponds to a damp runway condition. At 30 minutes after wetting the friction coefficient can be considered a dry pavement condition. The curves in Figures 11 through 14 were extrapolated, if necessary, to obtain friction coefficients at those time intervals. These data indicate the rate the pavement skid resistance properties were recovered after the test sections were wetted. By comparing the actual values of μ shown in Table 4 with the expected aircraft response in the associated rating guide, Table 5, it is possible to evaluate aircraft hydroplaning potential.

Measured pavement slopes are shown in Table 6. Positive transverse slopes indicate that water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate that water crosses the runway centerline before draining to the edge. Positive longitudinal slopes indicate rising pavement grades in the direction of increasing runway stations while negative longitudinal slopes indicate falling grades in the direction of increasing stations.

DISCUSSION OF RESULTS

Condition Survey Results

Changes in total weighted defect densities since the 1970 condition survey (Reference 1) reflect the maintenance efforts of the station Public Works forces. Spall repair and joint sealing has reduced or held relatively constant the numbers of these defects. The asphaltic concrete pavement, discrete area R14R-1, exhibits a substantial increase in the amount of pattern cracking since 1970. An analysis of changes in each discrete area is given in the Discrete Area Condition Analysis sheets, pages 41 through 45 .

Runway Friction Measurements

The wet (3 minute) friction coefficients given in Table 4 show that Runway 14R-32L has frictional resistance ranging from unacceptable to fair according to the guidelines in Table 5. The low friction coefficients are primarily attributed to poor surface drainage, smooth pavement surface texture, ponded water, and, to a lesser extent, tire rubber deposits. The surface drainage is characterized by transverse slopes averaging approximately 0.5 percent. Present runway design standards recommend minimum transverse slopes of 1.0 percent. The slurry seal placed on the runway in 1965 has a fine surface texture resulting in water depths above aggregate peaks. Evidence of ponded water was noted in References 1 and 2 and is probably the cause of large variations in friction coefficients shown in Figures 7 and 8.

The section of Runway 14L-32R constructed in 1946 (Discrete Area R14L-1) yielded (3 minutes) wet friction coefficients in the marginal category. These values are attributed to poor surface drainage and the possible existence of polished surface aggregate. Rubber deposits that are visible in Figure 1 and that were included in Test Section D had no noticeable effect on friction coefficients.

RECOMMENDATIONS FOR FURTHER EVALUATION EFFORT

A comprehensive pavement evaluation was performed at NAS Moffett Field by NCEL in 1965 (See Reference 2). That evaluation indicated that Runway 14R-32L should not be overloaded by aircraft. The pronounced increase in pattern cracking noted in 1975 suggests that a reduction in load-carrying capacity has occurred. It is recommended that the asphaltic concrete portion of Runway 14R-32L be considered for evaluation in accordance with NAVFAC Design Manual DM-21.

REFERENCES:

1. U.S. Naval Civil Engineering Laboratory. Technical Note N-1120, Airfield Pavement Condition Survey - USNAS Moffett Field, California, by D. J. Lambiotte and R. B. Brownie, Port Hueneme, California, August 1970
2. U.S. Naval Civil Engineering Laboratory. Internal Working Paper: Airfield Pavement Evaluation - USNAS Moffett Field, California, by R. J. Lowe and W. H. Chamberlin, Port Hueneme, California, February 1966

TABLE 1. AIRCRAFT OPERATIONS DATA,
USNAS MOFFETT FIELD, CALIFORNIA

<u>DATE</u>	<u>NUMBER OF OPERATIONS</u>
July 1973	4898
August	5809
September	4972
October	4172
November	4244
December	3981
January 1974	4672
February	4432
March	6002
April	5833
May	4144
June	<u>4077</u>
Total operations for above 1 year period	57,236
Average Monthly Operations	4770

TABLE 2. TYPES OF AIRCRAFT USING
USNAS MOFFETT FIELD, CALIFORNIA

Primary aircraft using NAS
Moffett Field:

P3

Other aircraft using NAS
Moffett Field:

A3, A4, A6, A7, C1, C5, C8, C9,
C47, C118, C130, C131, C135,
C141, T2, T28, T29, T38, T39,
T42, P2, U2, U8, U10, U11, H3,
H12, H47, H52, H53, H58, F4, F8,
F106, and numerous small civilian
type aircraft.

TABLE 3. DEFECT SEVERITY WEIGHTS,
USNAS MOFFETT FIELD, CALIFORNIA

<u>Asphaltic Concrete</u>		<u>Portland Cement Concrete</u>	
<u>Defect</u>	<u>Weight</u>	<u>Defect</u>	<u>Weight</u>
Depression	9.0	Depression	9.0
Rutting	9.0	Shattered Slab	9.0
Broken-up Area	9.0	Faulting	8.5
Faulting	8.5	Spalling	7.5
Raveling	7.0	Scaling	7.0
Erosion-Jet Blast	7.5	"D-Line" Cracking	6.5
Longitudinal, Transverse, or Longitudinal Construction Joint Crack	3.0	Pumping	4.0
Pattern Cracking	3.0	Poor Joint Seal	3.0
Patching	3.5	Corner Break	3.0
Reflection Crack	1.5	Intersecting Crack	3.0
Oil Spillage	1.5	Longitudinal or Transverse Crack	1.5

TABLE 4. RUNWAY FRICTION MEASUREMENT SUMMARY,
USNAS MOFFETT FIELD, CALIFORNIA

Test Location	Average Friction Coefficients		
	3 Min. (Mu)	15 Min. (Mu)	30 Min. (Mu)
Runway 14R - 32L			
Test Section A	0.18	0.48	0.60
Test Section B	0.25	0.50	0.60
Test Section C	0.47	0.70	0.73
Test Section D	0.26	0.42	0.47
Runway 14L - 32R			
Test Section A	0.56	0.73	0.75
Test Section B	0.36	0.55	0.60
Test Section C	0.39	0.59	0.61
Test Section D	0.40	0.64	0.66

TABLE 5. MU-METER AIRCRAFT PAVEMENT RATING

Mu	Expected Aircraft Braking Response	Hydroplaning Potential
Greater than 0.50	Good	No hydroplaning problems are expected
0.42 - 0.50	Fair	Transitional
0.25 - 0.41	Marginal	Potential for hydroplaning for some aircraft exists under certain wet conditions
Less than 0.25	Unacceptable	Very high probability for most aircraft to hydroplane

TABLE 6. RUNWAY PAVEMENT SLOPES
USNAS MOFFETT FIELD, CALIFORNIA

Location	Transverse Slopes				Longitudinal Slopes Percent
	Percent	Left Percent	Center Percent	Right Percent	
Runway 14R - 34L					
0 + 00	+0.6	+0.4	+0.3	+0.3	+0.6
5 + 00	+0.6	+0.6	+0.2	+0.3	+0.3
10 + 00	+0.5	+1.1	+0.3	+0.4	+0.1
15 + 00	+0.7	+0.6	+0.5	0.0	0.0
20 + 00	+0.9	+0.6	+0.4	+0.4	+0.3
25 + 00	+0.6	+0.9	+0.7	+0.1	+0.6
30 + 00	+0.4	+0.6	+0.3	+0.4	+0.1
35 + 00	+0.7	+0.7	+0.6	+0.4	+0.4
40 + 00	+0.4	+0.7	+1.1	+0.4	+0.3
45 + 00	+0.4	+1.2	+0.7	+0.6	+0.4
50 + 00	+0.4	+0.7	+0.9	+0.4	+0.3
55 + 00	+0.3	+1.1	+0.3	+0.6	+0.3
60 + 00	+0.7	+0.6	+0.7	+0.6	+0.4
65 + 00	+0.6	+1.2	+1.6	+0.8	+0.7
70 + 00	+0.2	+0.2	+0.7	+0.4	+0.7
75 + 00	+0.5	+0.4	+0.5	+0.3	+0.3
80 + 00	+0.3	+0.3	0.0	+0.1	0.0
Runway 14L - 32R					
0 + 00	0.0	0.0	+0.2	+0.7	0.0
5 + 00	0.0	0.0	+0.1	+0.2	-0.3
10 + 00	+ 0.3	+0.3	+0.3	+0.3	-0.3
15 + 00	+ 0.3	0.0	-0.3	-0.6	0.0
20 + 00	+ 0.5	+0.2	-0.3	-0.2	-0.1
25 + 00	+ 0.7	+0.2	-0.2	-0.2	+0.1
30 + 00	+ 0.7	+0.3	-0.1	0.0	+0.3
35 + 00	+ 0.5	+0.6	-0.1	0.0	+0.3
40 + 00	+ 0.4	+0.6	-0.4	-0.3	+0.5
45 + 00	+ 0.4	+0.4	-0.3	-0.1	+0.1
50 + 00	+ 0.7	+0.6	-0.3	-0.2	0.0
55 + 00	+ 0.6	+0.4	-0.1	-0.1	+0.5
60 + 00	+ 0.4	+0.3	-0.3	-0.4	+0.8
65 + 00	+ 0.7	+0.6	-0.3	-0.3	+0.3
70 + 00	+ 0.7	+0.7	+0.1	0.0	+0.6
75 + 00	+ 0.5	+0.6	-0.5	-0.4	+0.1
80 + 00	+ 0.2	+0.4	-0.4	-0.4	+0.6
85 + 00	+ 0.3	+0.4	-0.4	-0.3	+0.4
90 + 00	+ 0.4	+0.6	+1.0	+1.3	-0.4

NOTE: Positive transverse slopes indicate water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate drainage across the centerline. Positive longitudinal slopes indicate rising grades in the direction of increasing runway stationing, while falling grades are negative.

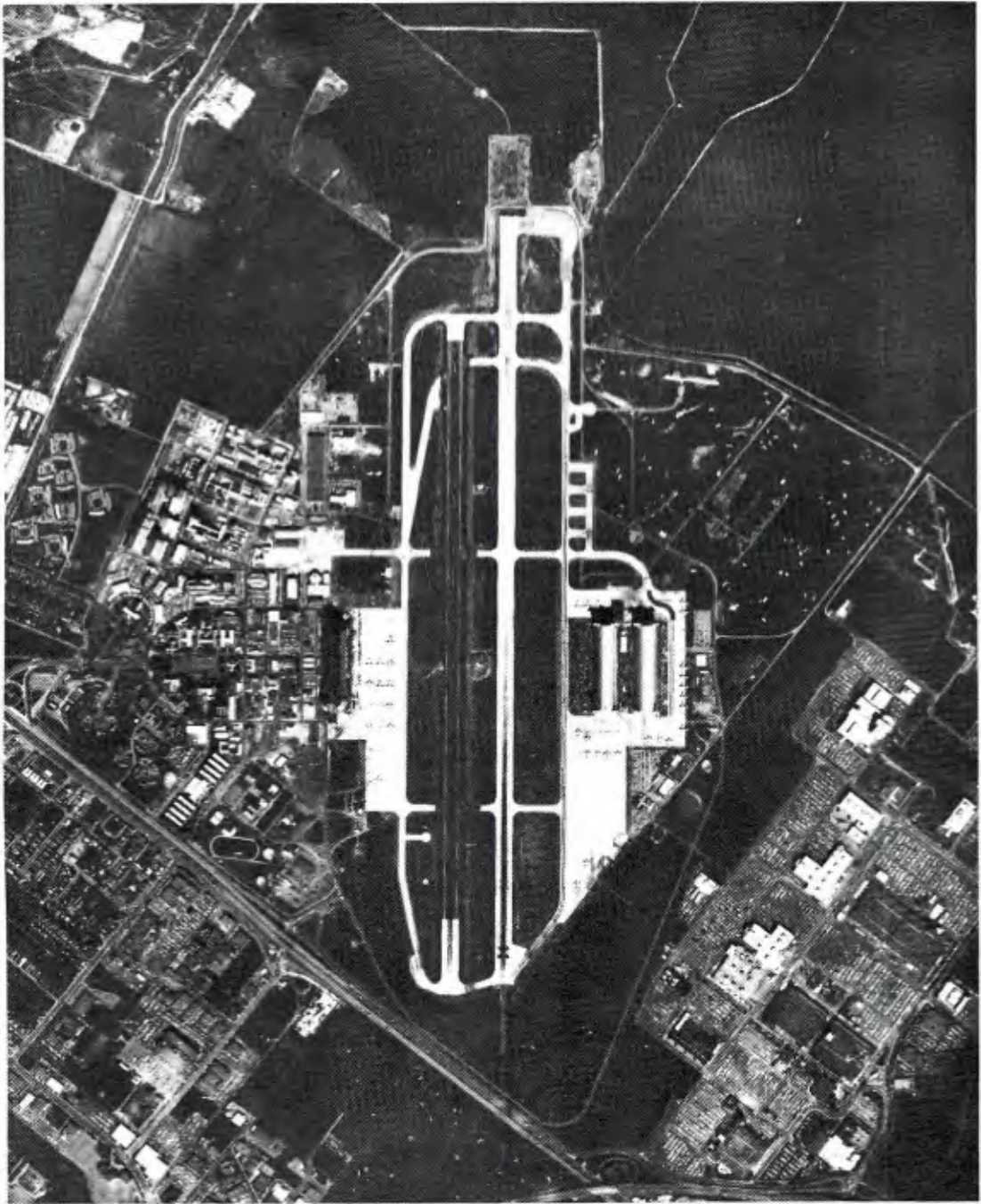


Figure 1. Aerial view of U.S. Naval Air Station, Moffett Field, California.



Figure 3. Pattern cracking, Discrete Area R14R-1.

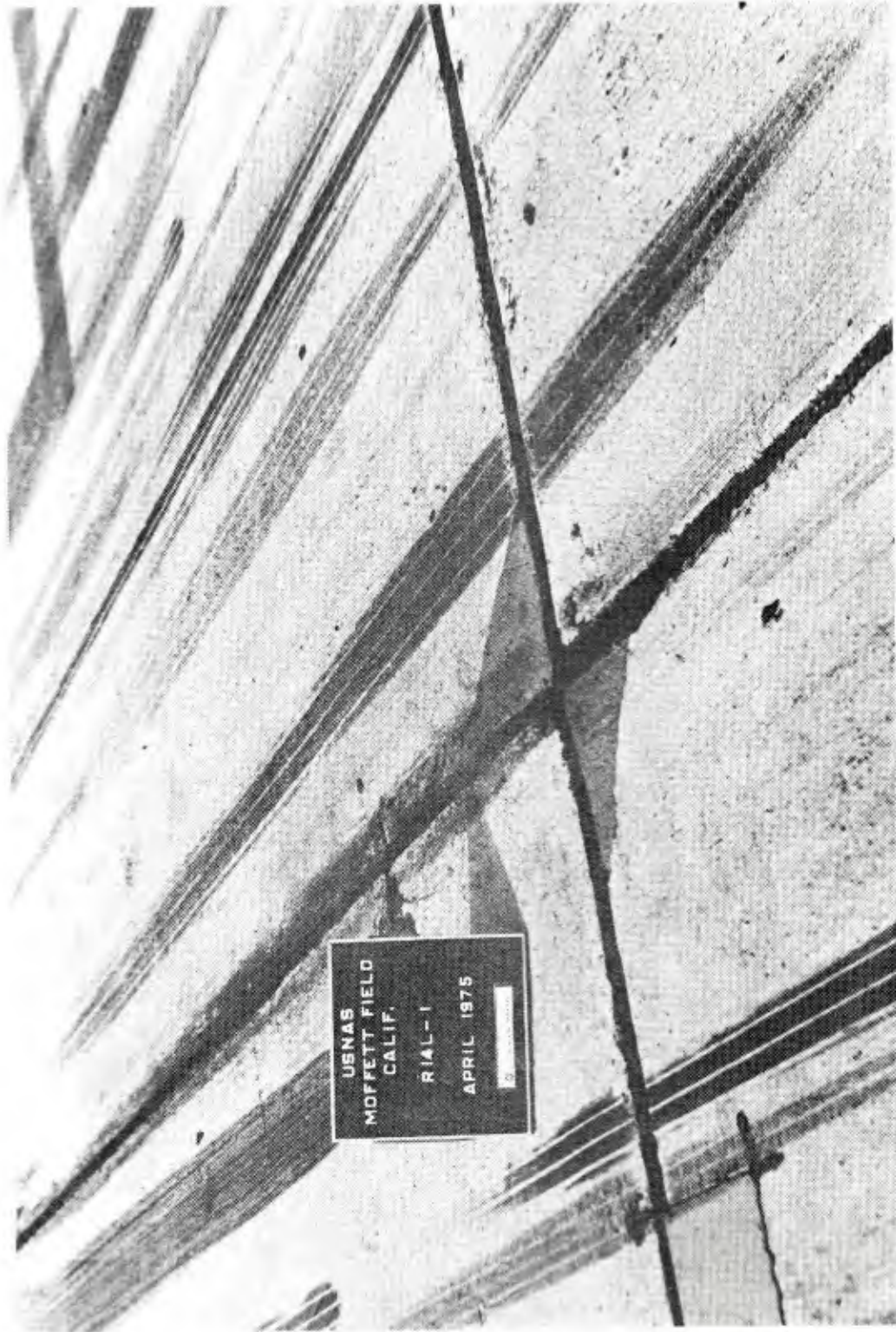


Figure 4. Epoxy concrete spall repair in good condition, Discrete Area R14L-1.

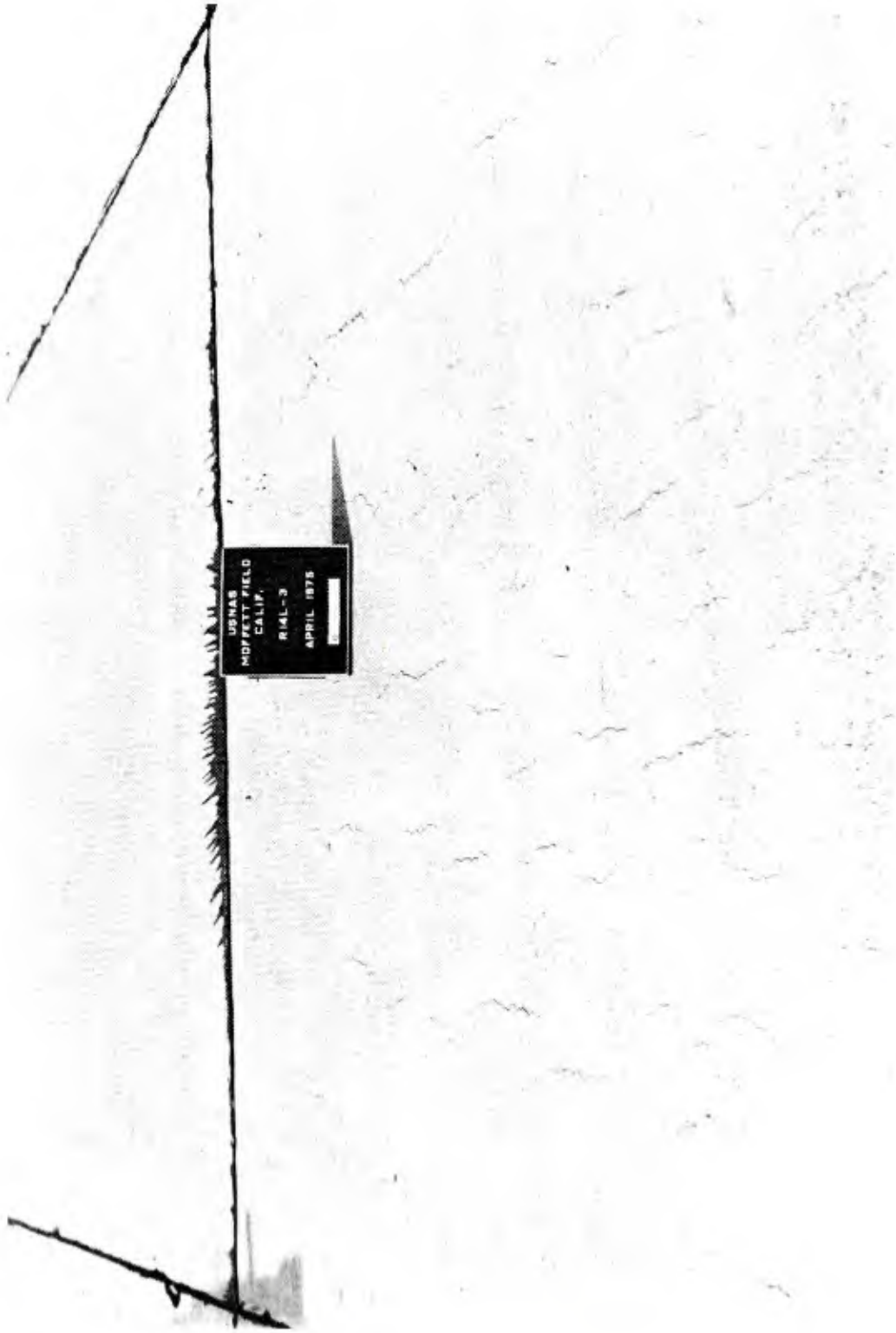
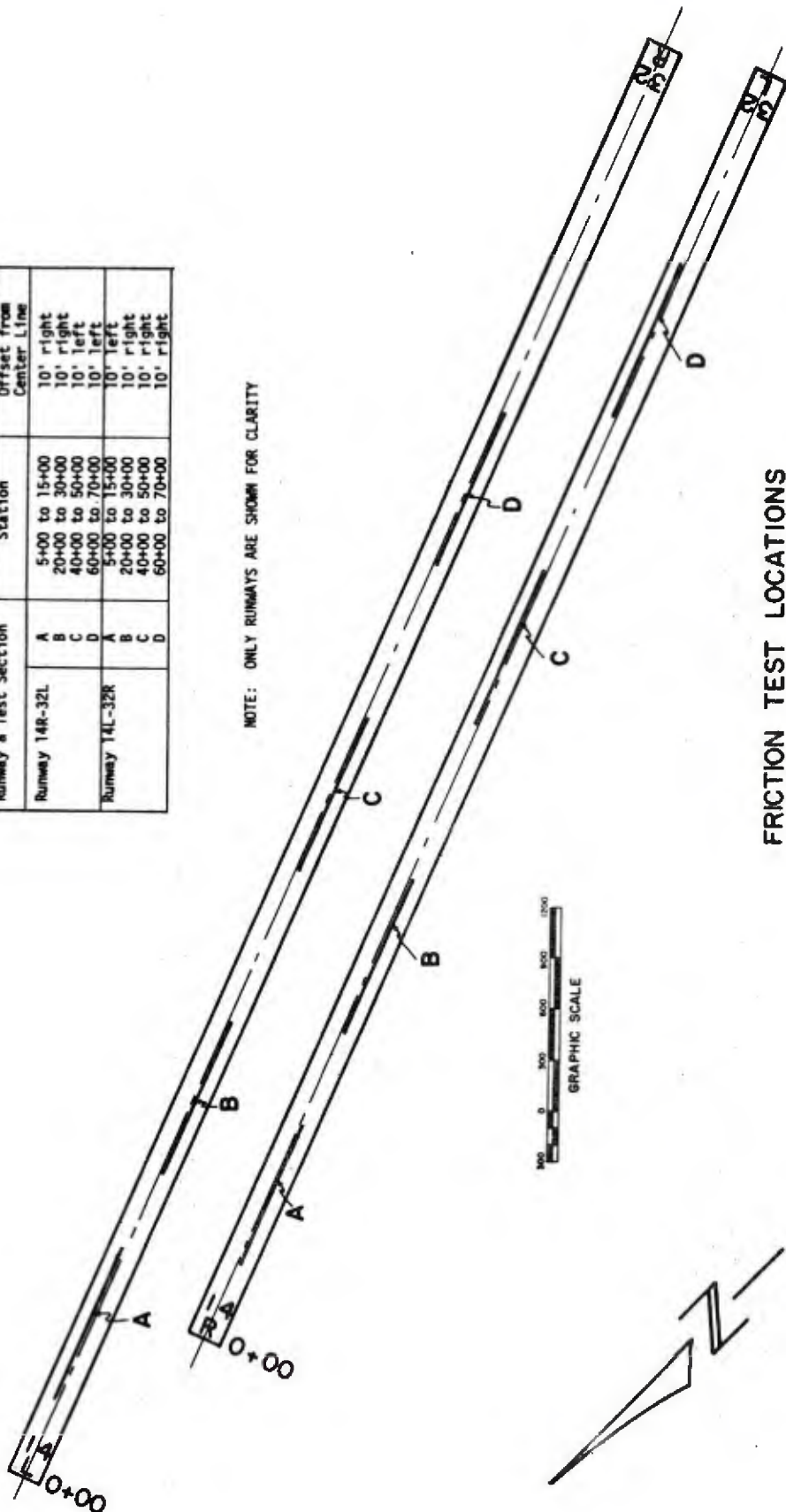


Figure 5. Shrinkage cracking, Discrete Area R14L-3.

Runway & Test Section	Station	Offset from Center Line
Runway 14R-32L	A	10' right
	B	10' right
	C	10' left
	D	10' left
Runway 14L-32R	A	10' left
	B	10' right
	C	10' right
	D	10' right



FRICION TEST LOCATIONS
USNAS MOFFETT FIELD, CALIF.

FIGURE 6

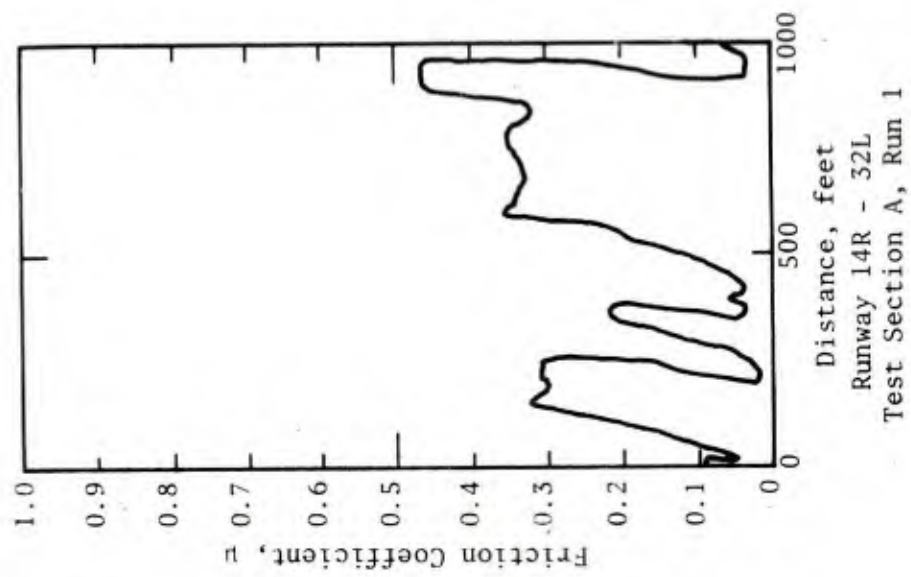
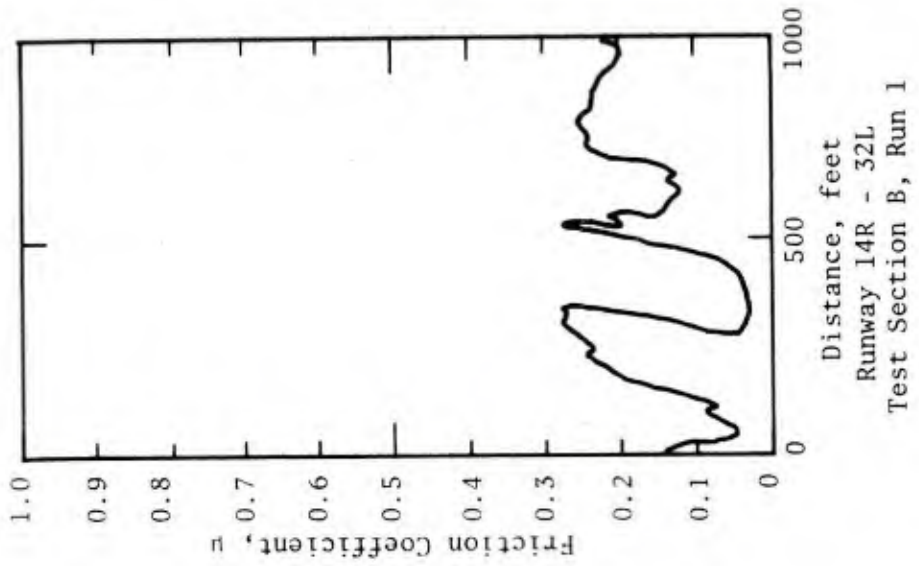


FIGURE 7. FRICTION COEFFICIENT VERSUS DISTANCE,
USNAS MOFFETT FIELD, CALIFORNIA

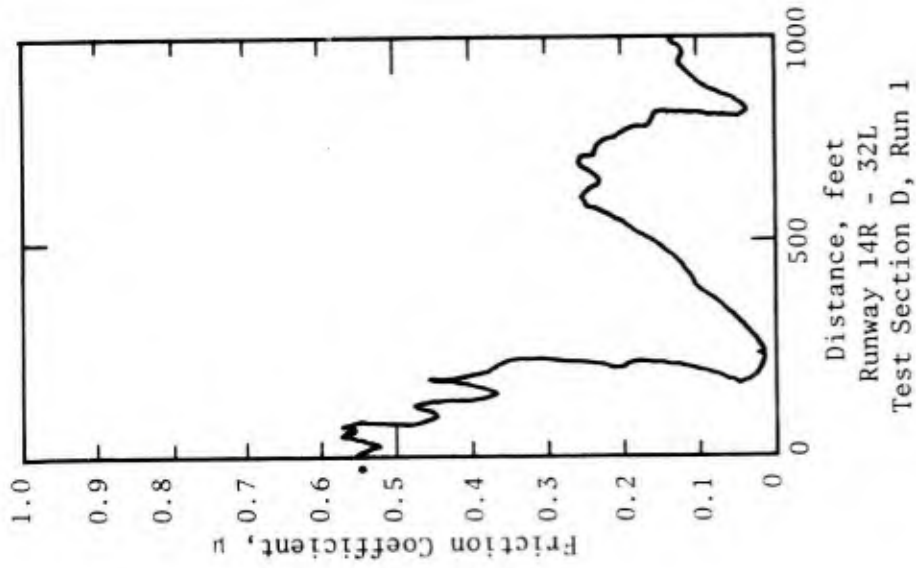
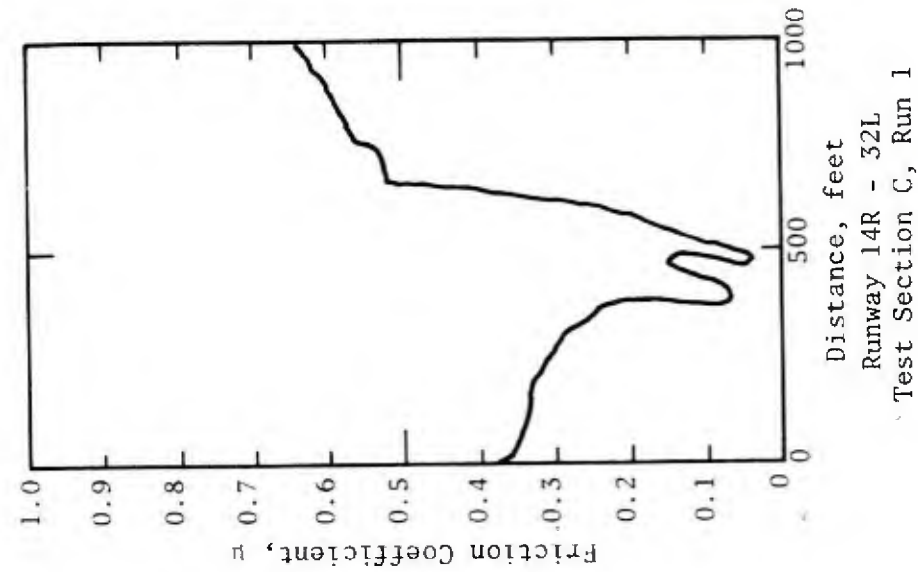


FIGURE 8. FRICTION COEFFICIENT VERSUS DISTANCE,
USNAS MOFFETT FIELD, CALIFORNIA

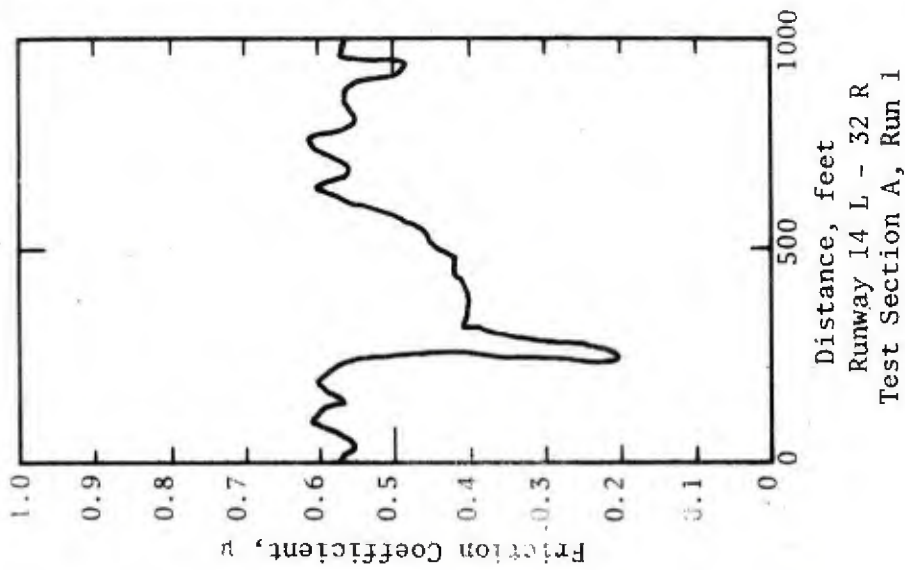
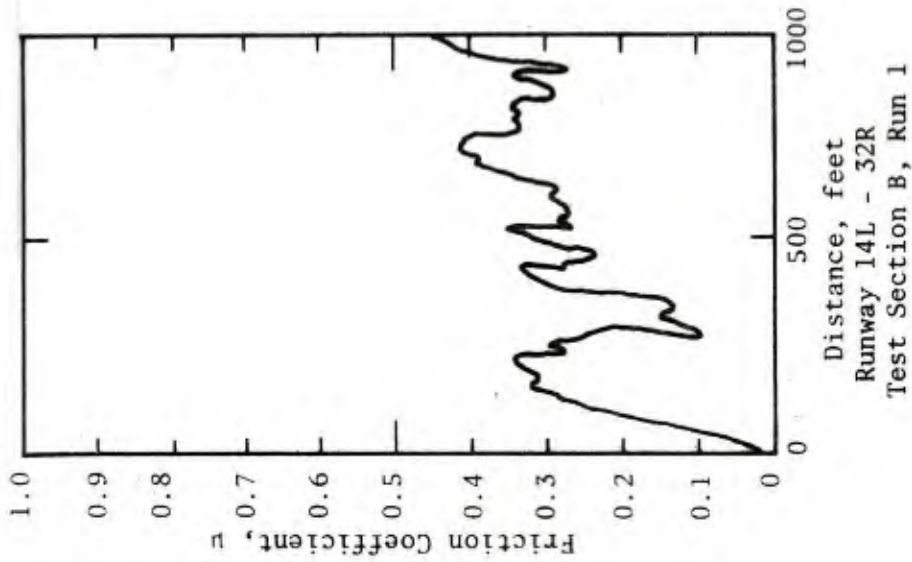


FIGURE 9. FRICTION COEFFICIENT VERSUS DISTANCE,
USNAS MOFFETT FIELD, CALIFORNIA

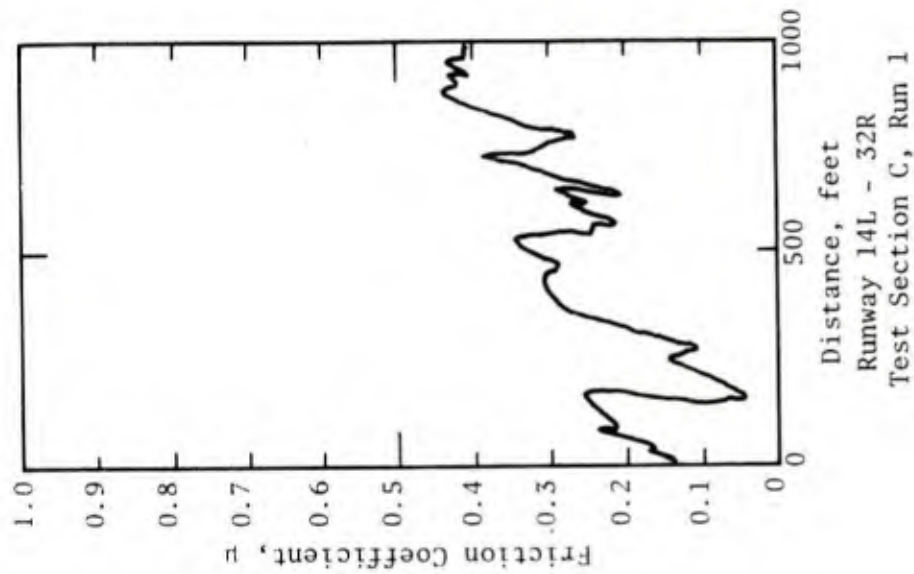
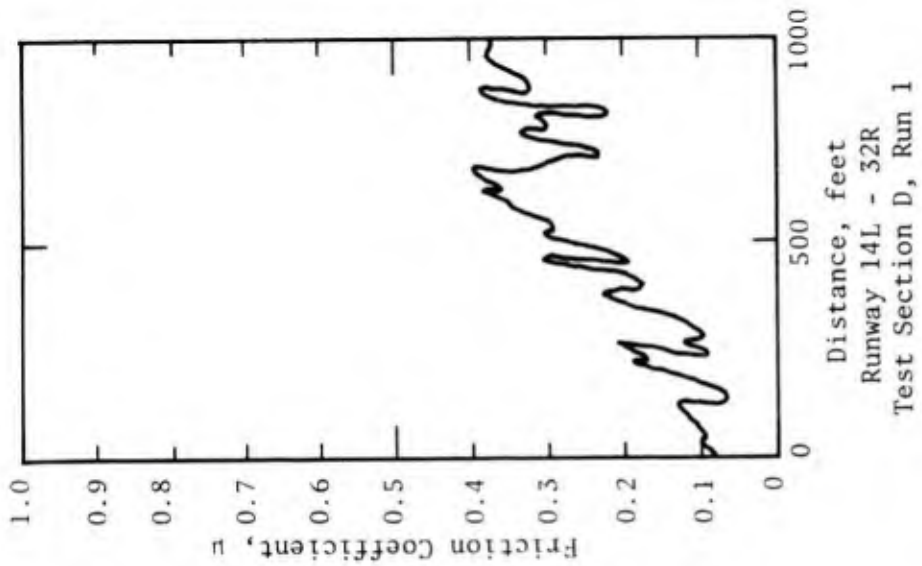


FIGURE 10. FRICTION COEFFICIENT VERSUS DISTANCE,
USNAS MOFFETT FIELD, CALIFORNIA

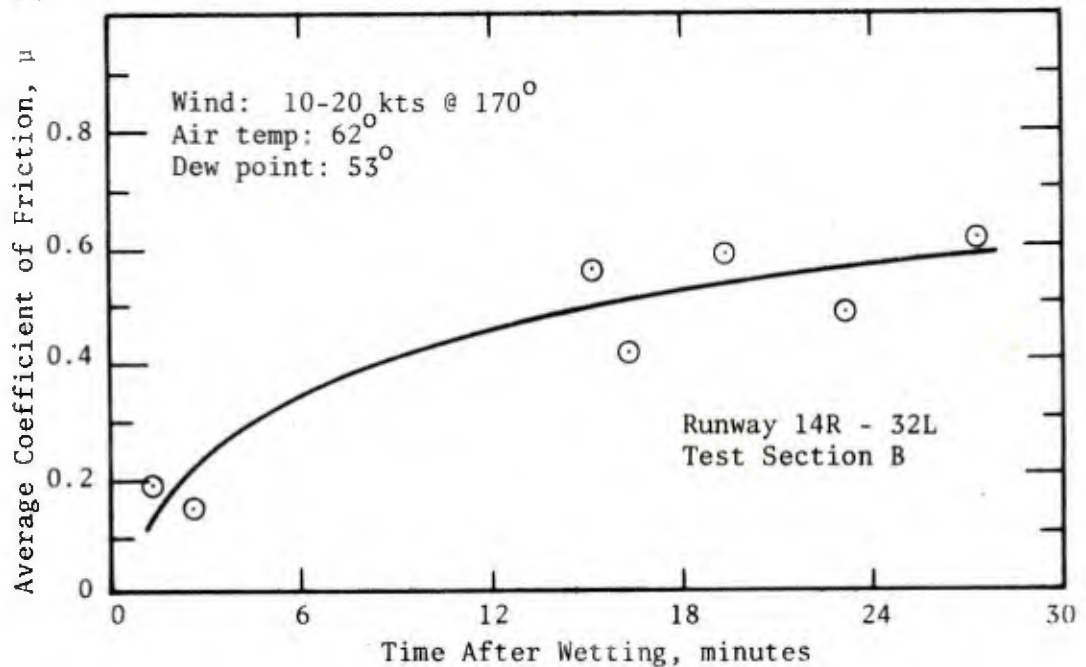
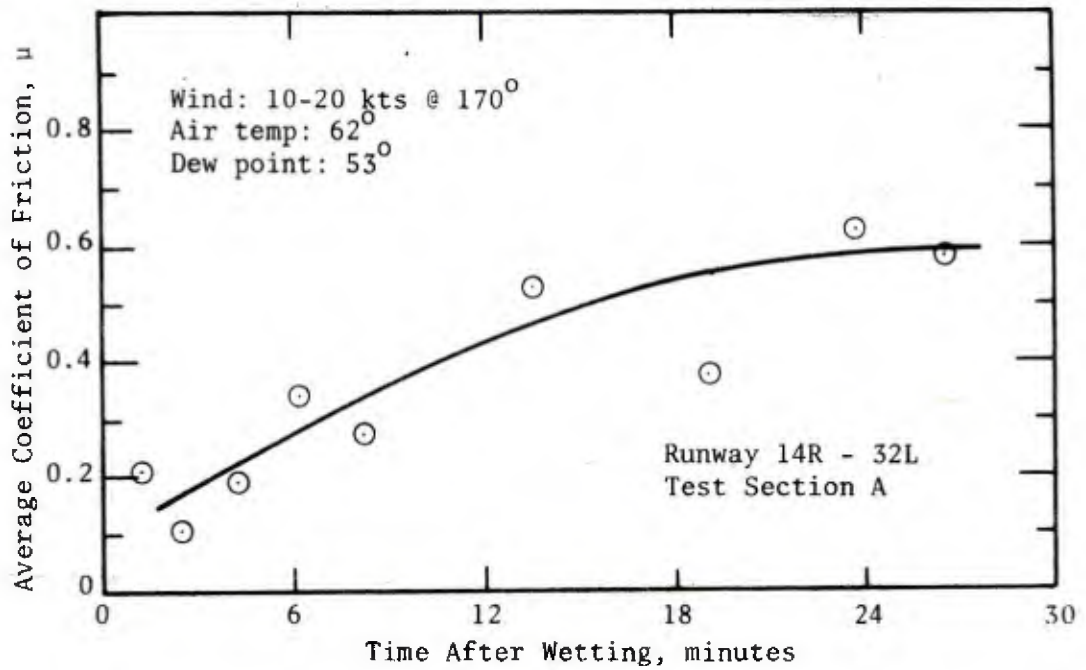


FIGURE 11. AVERAGE FRICTION COEFFICIENT VERSUS TIME AFTER WETTING, USNAS MOFFETT FIELD, CALIFORNIA

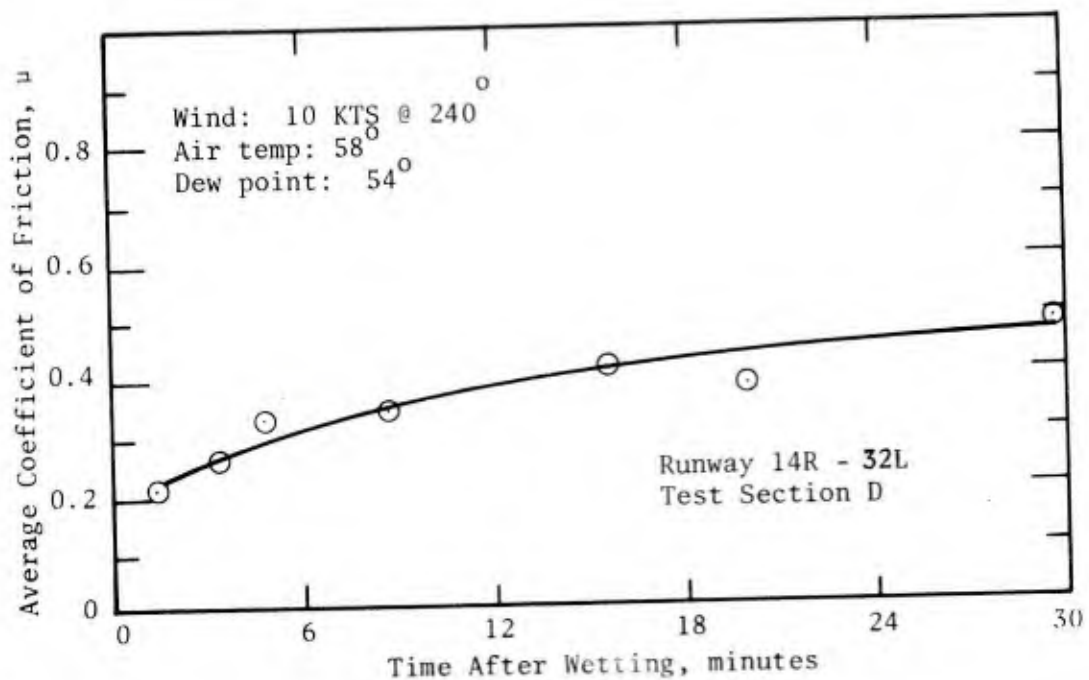
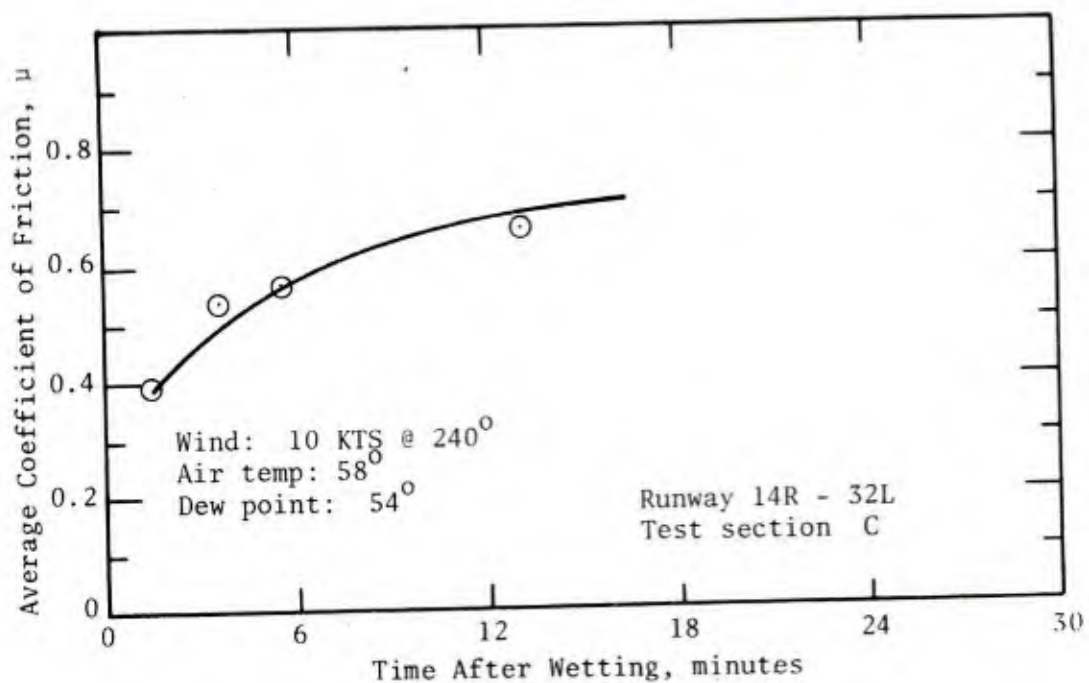


FIGURE 12. AVERAGE FRICTION COEFFICIENT VERSUS TIME AFTER WETTING, USNAS MOFFETT FIELD, CALIFORNIA

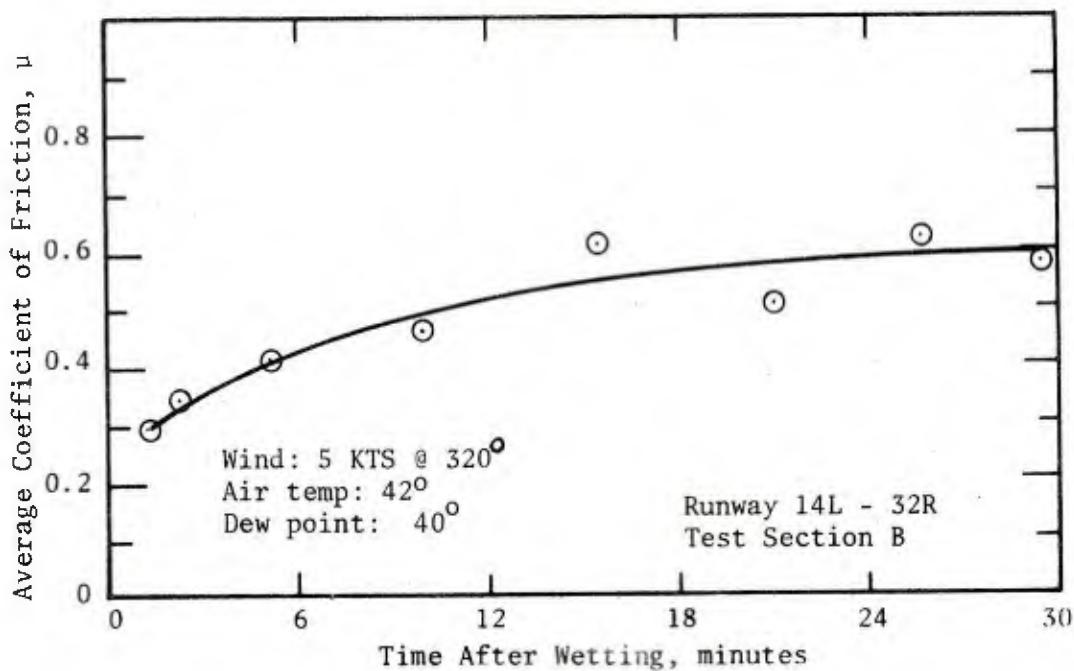
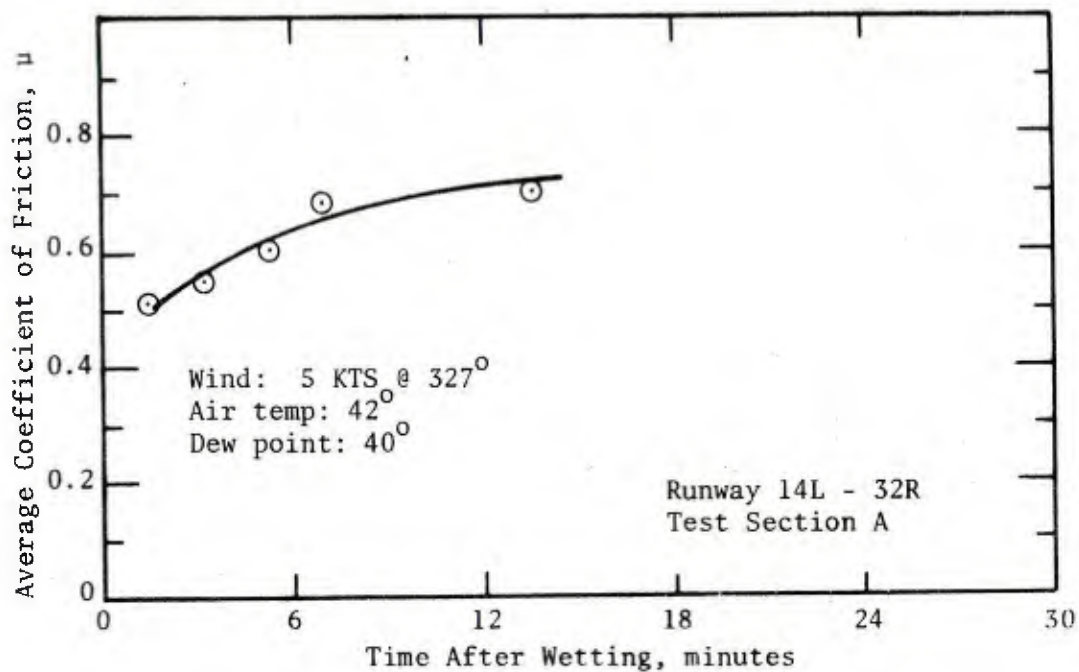


FIGURE 13. AVERAGE FRICTION COEFFICIENT VERSUS TIME AFTER WETTING, USNAS MOFFETT FIELD, CALIFORNIA

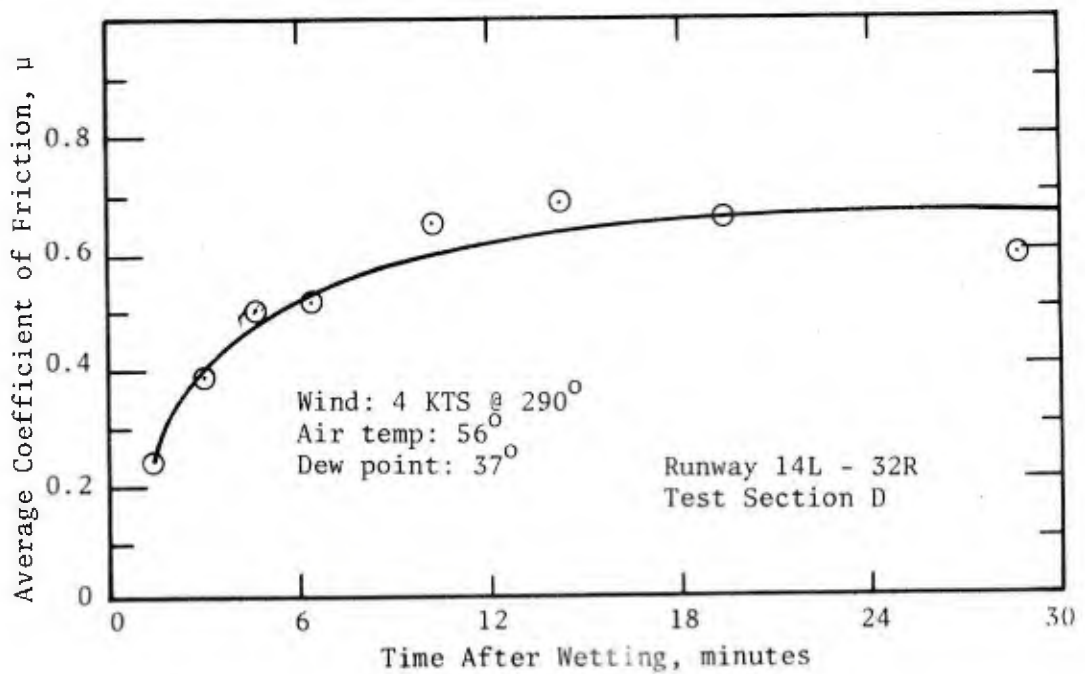
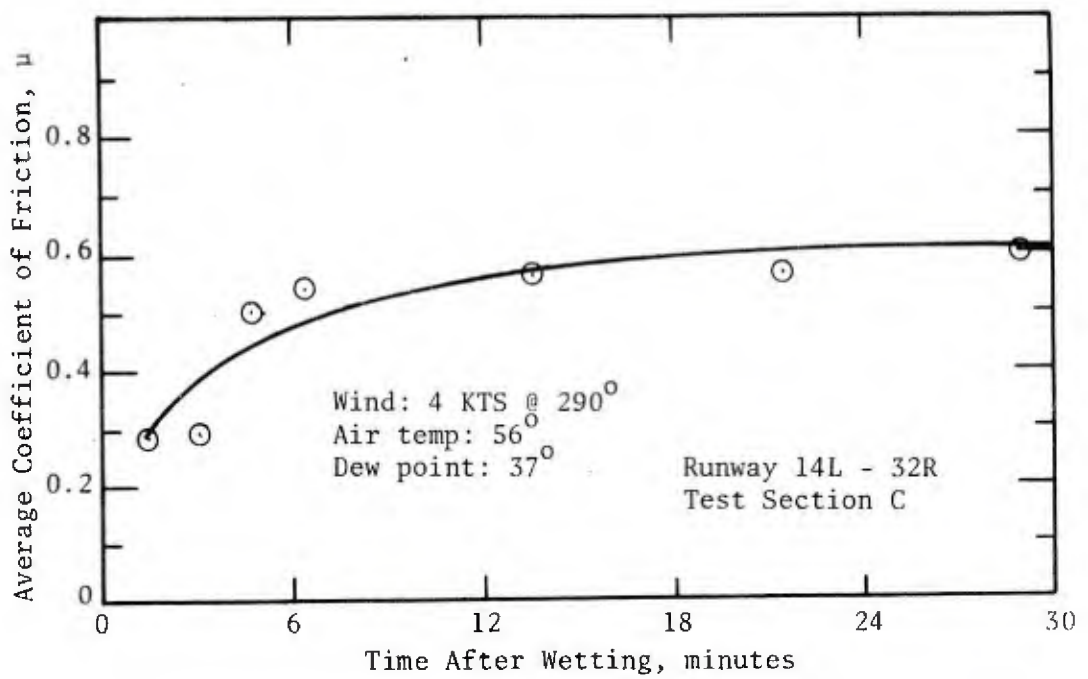


FIGURE 14. AVERAGE FRICTION COEFFICIENT VERSUS TIME AFTER WETTING, USNAS MOFFETT FIELD, CALIFORNIA

DISCRETE AREA DEFECT SUMMARIES

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield NAS Moffett Field Facility Runway 14R-32L

Discrete Area R14R-1 Area of Discrete Area (a) 700,000 ft²

No. of Sample Areas (b) 16 Ratio: (a/2500b) 17.5

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	903 ft.	15,803 ft.	0.226	3.0	0.68
Reflection Crack					
Faulting					
Patching	14 ft. ²	245 ft. ²	0.004	3.5	0.01
Settlement or Depression					
Pattern Cracking	2,663 ft. ²	46,603 ft. ²	0.66	3.0	0.02
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
Total					2.71A
Remarks on Pavement Condition					
<p>Longitudinal and longitudinal construction joint cracks were unsealed and up to ¼ inch wide. Water stains were noted along the longitudinal cracks. The slurry seal was peeling under the paint stripes. Pattern cracking progressed outward from the longitudinal construction joint cracks as can be seen in Figure 3.</p>					

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield NAS Moffett Field Facility Runway 14R-32L

Discrete Area R14R-2 Total Slabs in Discrete Area (a) 201

No. of Slabs Sampled (b) 50 Ratio a/b = 4.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	8	32	0.159	1.5	0.24
I.C.**					
Depression					
Spalling	14	56	0.279	7.5	2.09
Scaling					
Shattered Slab					
Joint Seal	18	72	0.358	3.0	1.07
Pumping					
"D-line" cracking					
Remarks on Pavement Condition					Total
					3.40C ***
<p>Unsealed transverse cracks less than 1/8 inch wide were found. Spalls were generally 1 inch wide. Joint seal was missing in short strips.</p>					

* Longitudinal crack or Transverse crack
 ** Intersecting crack
 *** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield NAS Moffett Field Facility Runway 14L-32R
 Discrete Area R14L-1 Total Slabs in Discrete Area (a) 4000
 No. of Slabs Sampled (b) 182 Ratio a/b = 22.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	8	176	0.044	1.5	0.07
I.C.**					
Depression					
Spalling	28	616	0.154	7.5	1.16
Scaling					
Shattered Slab	2	44	0.011	9.0	0.10
Joint Seal	18	396	0.099	3.0	0.30
Pumping					
"D-line" cracking					
Total					1.63C
<p style="text-align: right;">***</p> <p>Remarks on Pavement Condition</p> <p>Many spall repairs, most in good condition, were noted (See Figure 4). Some small spalls had occurred on spall repairs. Most cracks were less than 1/8 inch wide, and some appeared to be superficial and not to penetrate the full depth of the slab. Six to twelve-inch strips of joint seal were missing or separated from the slab.</p>					

* Longitudinal crack or Transverse crack
 ** Intersecting crack
 *** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield NAS Moffett Field Facility Runway 14L-32R

Discrete Area R14L-2 Total Slabs in Discrete Area (a) 82

No. of Slabs Sampled (b) 21 Ratio a/b = 4.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	2	8	0.097	1.5	0.15
I.C.**					
Depression					
Spalling	4	16	0.195	7.5	1.46
Scaling					
Shattered Slab					
Joint Seal	4	16	0.195	3.0	0.89
Pumping					
"D-line" cracking					
Total					2.50C
<p style="text-align: right;">Remarks on Pavement Condition: _____</p> <p>Spalls were less than 1 inch wide and 3 inches long. Transverse cracks were less than 1/8 inch wide and unsealed. Joint seal was missing in short strips.</p>					

* Longitudinal crack or Transverse crack

** intersecting crack

*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield NAS Moffett Field Facility Runway 14L-32R

Discrete Area R14L-3 Total Slabs in Discrete Area (a) 640

No. of Slabs Sampled (b) 160 Ratio a/b = 4.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	1	4	0.006	1.5	0.01
I.C.**					
Depression					
Spalling	13	52	0.081	7.5	0.61
Scaling					
Shattered Slab					
Joint Seal	24	96	0.150	3.0	0.45
Pumping					
"D-line" cracking					

Total **1.07C** ***

Remarks on Pavement Condition: The slabs in this discrete area have many shrinkage cracks as shown in Figure 5. Spalls were small, some occurring on shrinkage cracks. The joint seal was shriveled.

* Longitudinal crack or Transverse crack
 ** Intersecting crack
 *** Letter suffix "C" represents PCC pavement

FACILITY DEFECT SUMMARIES

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY

Airfield USNAS Moffett Filed

Date Surveyed April 1975

Facility (or portion)	Weighted Defect Density Total	Ratio: <u>Discrete Area</u> Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
<u>1975 Condition Survey</u>			
Runway 14R-32L R14R-1	2.71A	1.00	2.71A
<u>1970 Condition Survey</u>			
Runway 14R-32L R14R-1	1.14A	1.00	1.14A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield USNAS Moffett Field

Date Surveyed April 1975

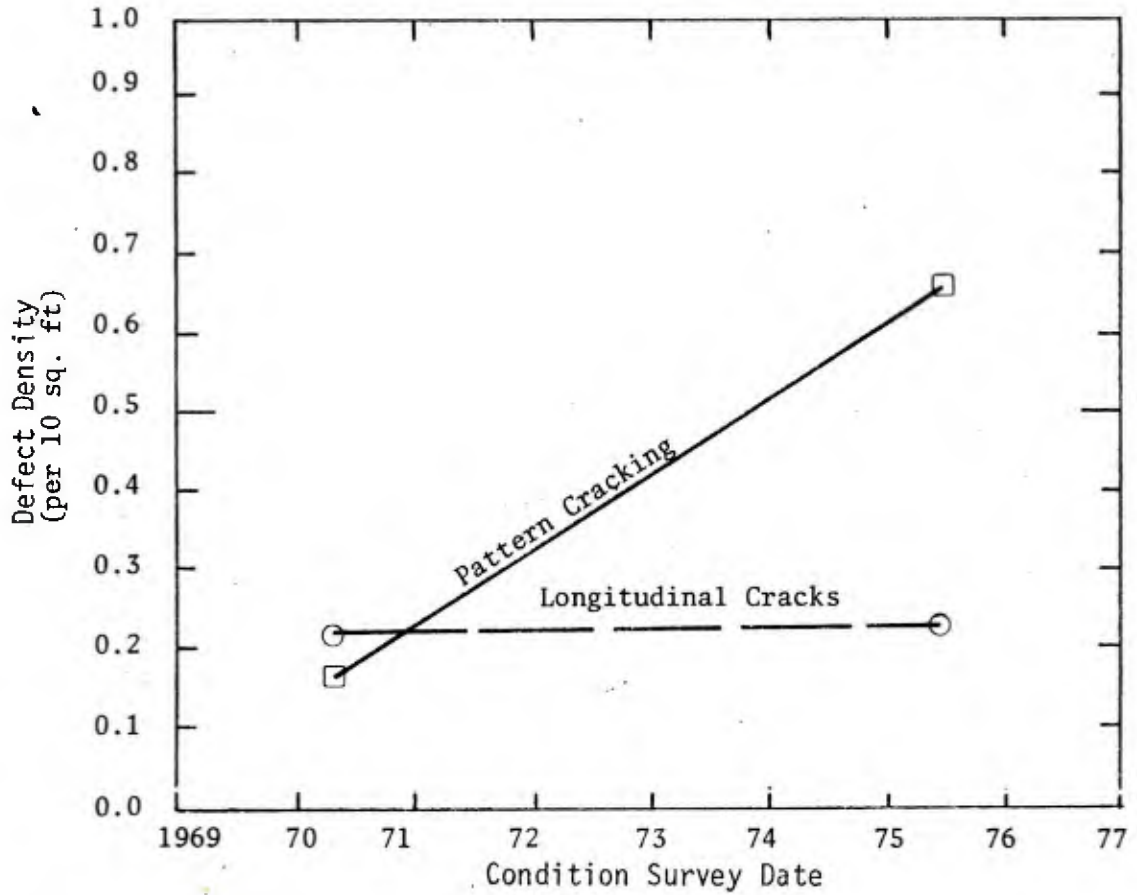
Facility (or portion)	Weighted Defect Density Total	Ratio: $\frac{\text{Discrete Area}}{\text{Total Facility Area}^*}$	Average Weighted Defect Density (a) x (b)
	(a)	(b)	(c)**
<u>1975 Condition Survey</u>			
Runway 14R-32L R14R-2	3.40C	1.00	3.40C
Runway 14L-32R R14L-1	1.63C	0.81	1.32
R14L-2	2.50C	0.06	0.15
R14L-3	1.07C	0.13	0.14
			<u>1.61C(Total)</u>
<u>1970 Condition Survey</u>			
Runway 14R-32L R14R-2	4.44C	1.00	4.44C
Runway 14L-32R R14L-1	2.25C	0.81	1.82
R14L-2	1.86C	0.06	0.11
R14L-3	1.11C	0.13	0.14
			<u>2.07C(Total)</u>

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on average weighted defect densities indicates Portland cement concrete pavements.

DISCRETE AREA CONDITION ANALYSIS

DISCRETE AREA CONDITION ANALYSIS



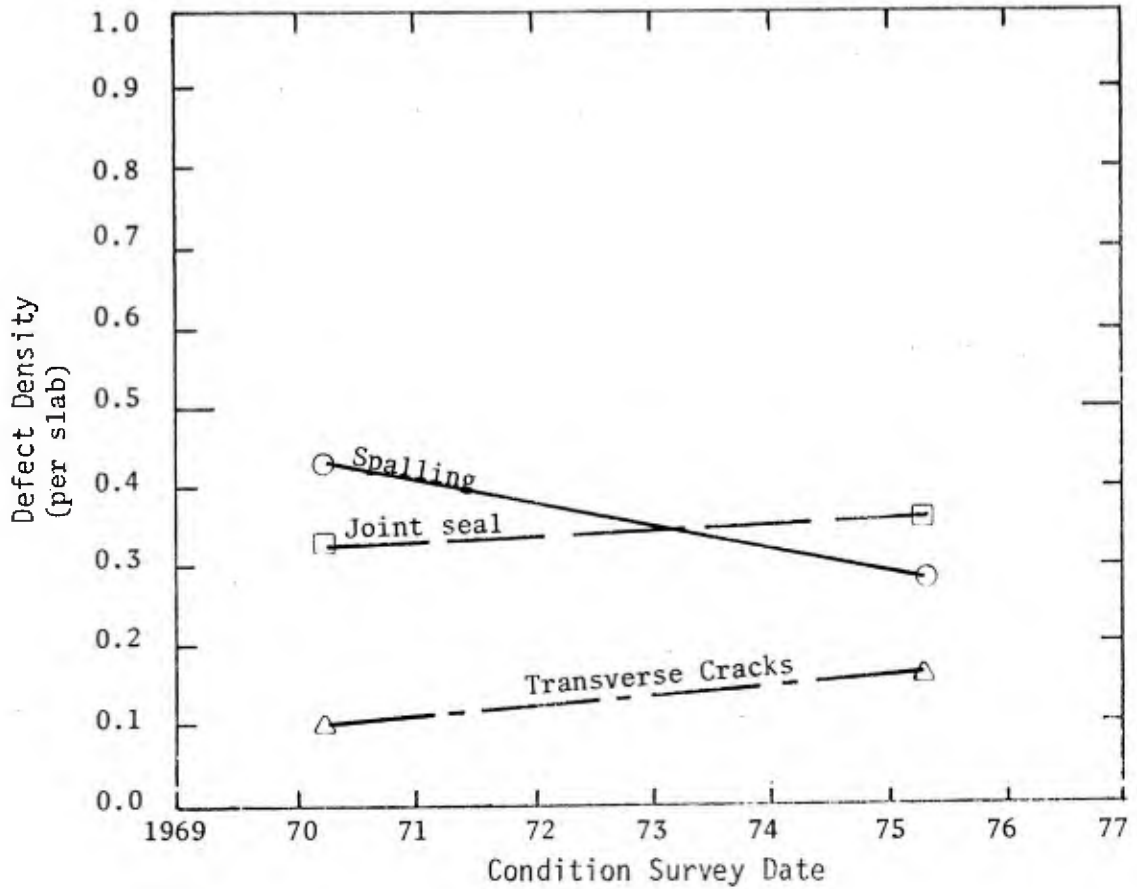
Airfield NAS Moffett Field Facility Runway 14R-32L

Discrete Area R14R-1 Pavement Type AC

Discussion

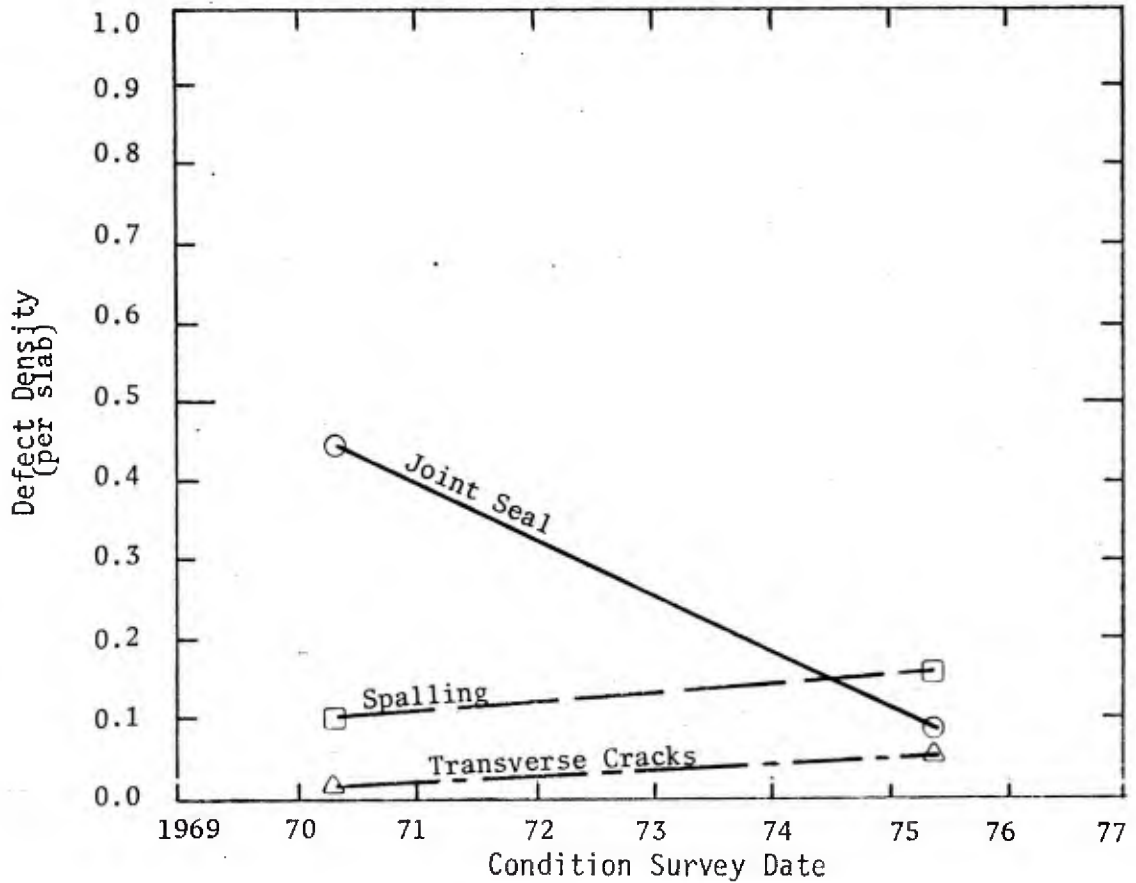
Pattern cracking has increased markedly. No major maintenance has been done on this area since a slurry seal was applied in 1965.

DISCRETE AREA CONDITION ANALYSIS



Airfield	NAS Moffett Field	Facility	Runway 14R-32L
Discrete Area	R14R-2	Pavement Type	PCC
Discussion			
<p>Public Works maintenance efforts have reduced the number of spalls. Public Works records show 208 hours of maintenance in recent years. Incidence of transverse cracks and joint seal defects has increased slightly.</p>			

DISCRETE AREA CONDITION ANALYSIS



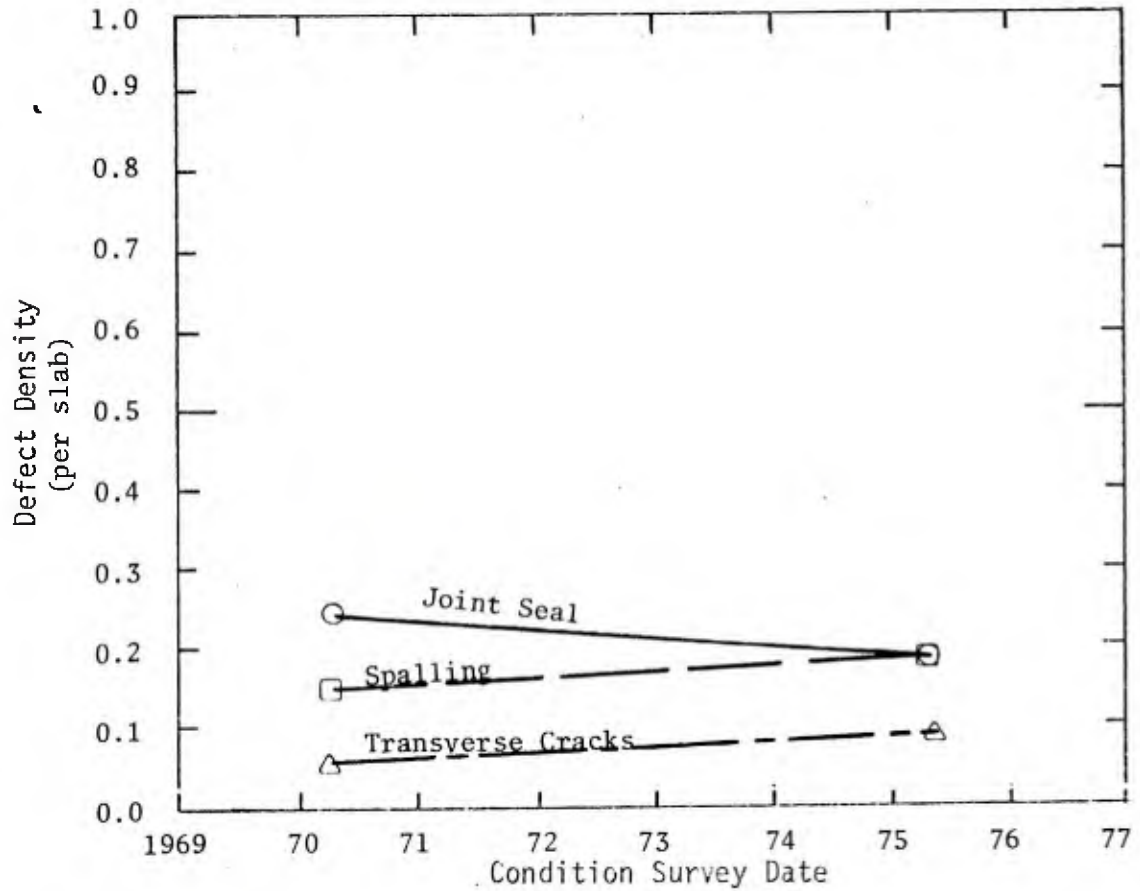
Airfield	NAS Moffett Field	Facility	Runway 14L-32R
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Discrete Area	R14L-1	Pavement Type	PCC
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Discussion

Joint seal repairs by Public Works have reduced the percentage of slabs with defective joint seal from 45 percent to 10 percent. Spalls and transverse cracks have increased slightly.

DISCRETE AREA CONDITION ANALYSIS



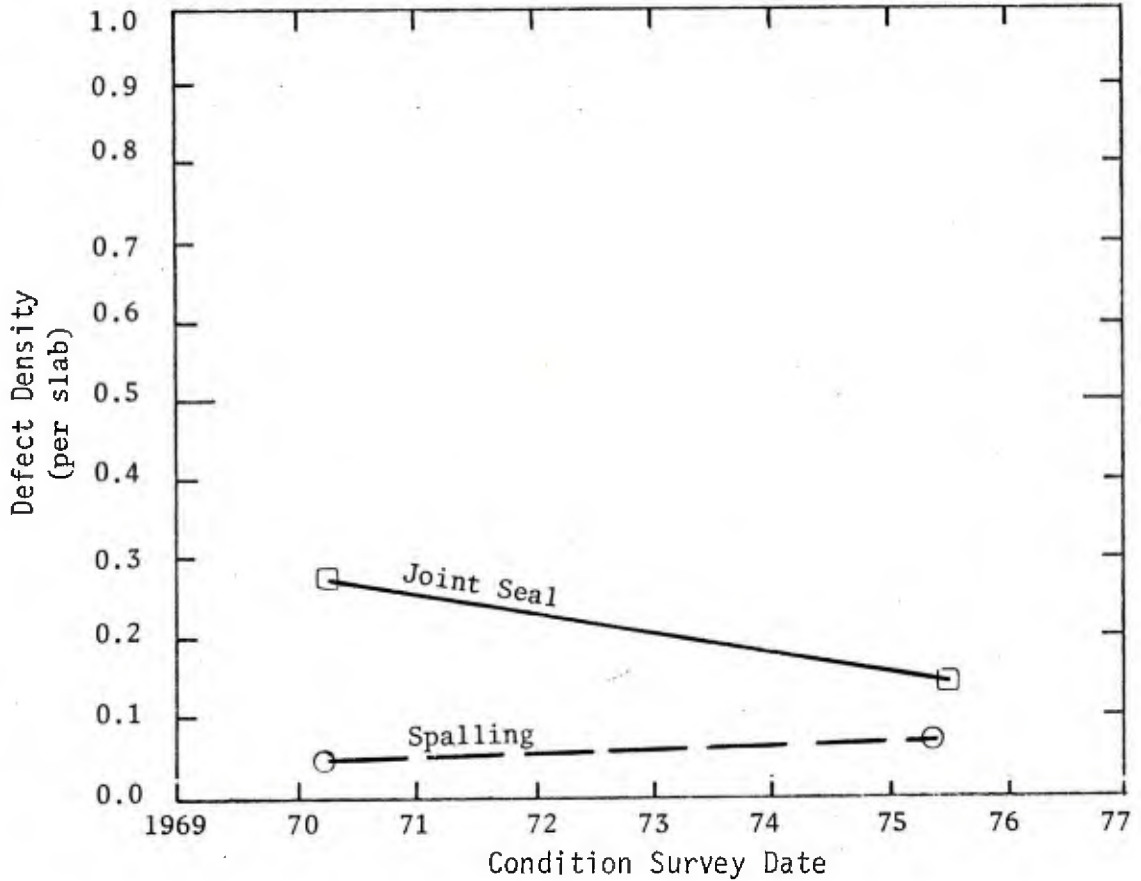
Airfield <u>NAS Moffett Field</u>	Facility <u>Runway 14L-32R</u>
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Discrete Area <u>R14L-2</u>	Pavement Type <u>PCC</u>
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Discussion

The number of slabs having defective joint seal has decreased, probably because of Public Works maintenance efforts.

DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Moffett Field Facility Runway 14L-32R
Discrete Area R14L-3 Pavement Type PCC
Discussion

As in the other discrete areas on Runway 14L-32R, the incidence of joint seal defects has decreased because of Public Works maintenance efforts.

APPENDIX A
CONSTRUCTION HISTORY

APPENDIX A

CONSTRUCTION HISTORY FOR USNAS MOFFETT FIELD, CALIFORNIA

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1	<u>Runway 14R-32L--</u> <u>Present Runway 200' x 8125'-</u> <u>Original Asphaltic Concrete Runway</u> <u>150' x 2410'</u>		
	Slurry seal		1965
	3" Asphaltic concrete		1953
	3" Bituminous base		1953
	3" Asphaltic concrete		1951 - 1952
	6"-12" Mechanically stabilized base		1951 - 1952
	4" Asphaltic concrete	1938	
	12" Pit run gravel	1938	
1A	<u>Extended North 1050', South 900'</u>		
	Slurry seal		1965
	3" Asphaltic concrete		1953
	3" Bituminous base		1953
	6"-12" Mechanically stabilized base		1951 - 1952
	4" Cold plant mix	1941	
	12" Pit run gravel	1941	
1B	<u>Extended North 1175', South 438'</u>		
	Slurry seal		1965
	3" Asphaltic concrete		1953
	3" Bituminous base		1953
	6"-12" Mechanically stabilized base		1951 - 1952
	4" Penetration macadam	1944	
	Asphaltic concrete	1944	
	12" Crusher run base	1944	
1C	<u>Extended North 1113' and Entire</u> <u>Runway Widened 50'</u>		
	Slurry seal		1965
	3" Asphaltic concrete		1953
	3" Bituminous base		1953
	3" Asphaltic concrete	1951 - 1952	
	24" Crusher run base	1951 - 1952	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1D	<u>Extended South 837'</u>		
	Joints resealed and spalls repaired (SS-S-167)		1970
	9" Reinforced portland cement concrete		1951 - 1952
	4" Penetration macadam	1944	
	Asphaltic concrete	1944	
	12" Crusher run base	1944	
1E	<u>Extended North 287'</u>		
	Joints resealed and spalls repaired (SS-S-167)		1970
	11" Portland cement concrete	1951 - 1952	
	16" Base, CBR 60, Plasticity Index 8	1951 - 1952	
Not Shown	<u>Shoulders 10' - Parallel Runway</u>		
	Slurry seal		1963
	2" Asphaltic concrete surface		
	4" Base		
	10" Subbase		
Not Shown	<u>Shoulders 140' - Parallel Runway</u>		
	MC 1 Prime		
	Single emulsion seal		
	28" - 0" Select fill		
2	<u>Runway 14L-32R--</u> <u>Present Runway 200' x 9200'-</u> <u>Original 7150'</u>		
	Joints resealed and spalls repaired (SS-S-167)		1970
	Joints resealed and spalls repaired (SS-S-164)		1966
	8" Reinforced portland cement concrete	1946	
	12" Crusher run base, CBR 90		
	4" Pea gravel with perforated 4" drains, 40' center to center		

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
2A	<u>Original South End 275'</u>		
	Joints resealed and spalls repaired		1966
	12" Portland cement concrete	1946	
	18" Crusher run base	1946	
2B	<u>Extended North 575'</u>		
	Joints resealed and spalls repaired		1966
	11" Portland cement concrete	1951 - 1952	
	16" Base, CBR 60, Plasticity Index 8	1951 - 1952	
2C	<u>Extended North 1200'</u>		
	11" Portland cement concrete	1956 - 1957	
	12" Base	1956 - 1957	
Not Shown	<u>Shoulders 10' - Parallel Runway</u>		
	Slurry seal		1963
	2" Asphaltic concrete surface		
	4" Base		
	10" Subbase		
3	<u>Portion of Taxiway - West</u>		
	8" Reinforced portland cement concrete	1946	
	12" Crusher run base, CBR 90		
	4" Pea gravel with perforated 4" drains, 40' center to center		
3A	<u>Portion of Taxiway - West</u>		
	11" Reinforced portland cement concrete	1951 - 1952	
	16" Base, CBR 60, Plasticity Index 8		

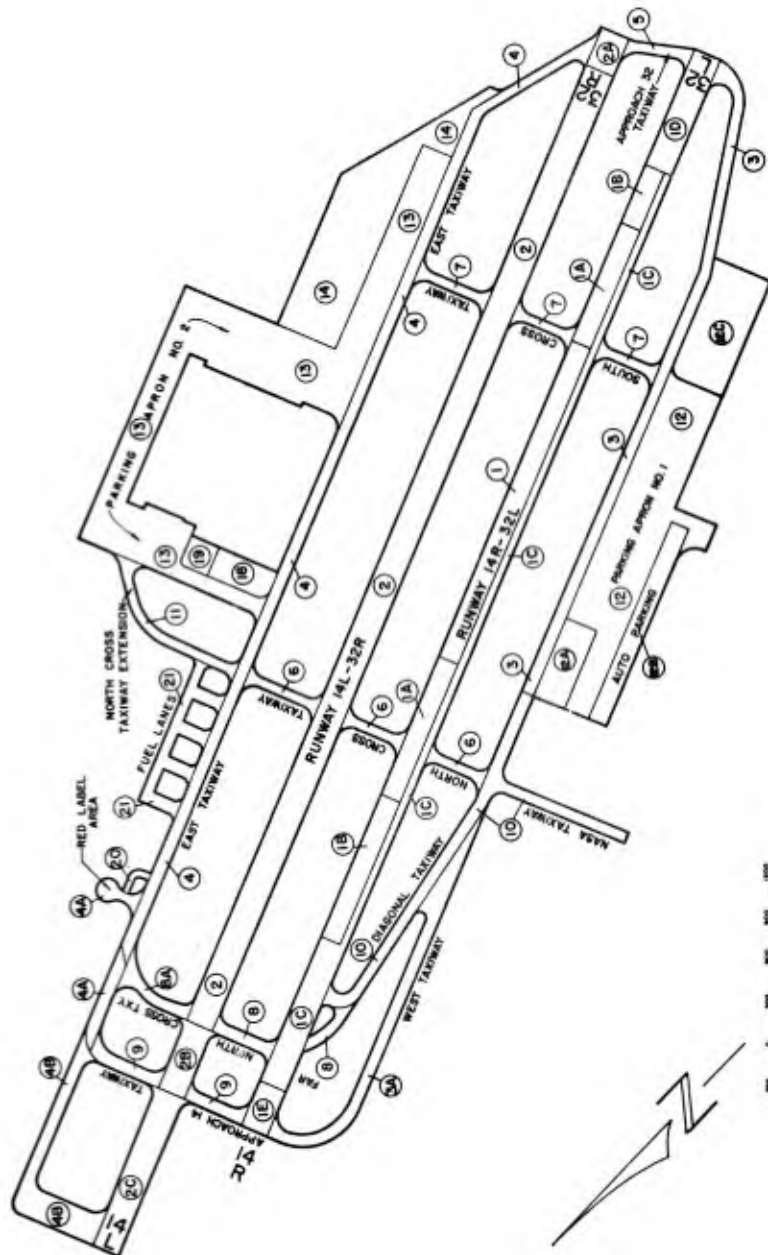
Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
4	<u>Portion of Taxiway - East</u> Incremental 2" asphaltic concrete overlay of the center 36' of taxiway Joints resealed (SS-S-164) 7" Reinforced portland cement concrete 10" Crusher run base, CBR 90 4" Pea gravel with perforated 4" drains, 40' center to center	1946	1972 1964
4A	<u>Portion of Taxiway - East</u> 11" Reinforced portland cement concrete 16" Base, CBR 60, Plasticity Index 8	1951 - 1952	
4B	<u>Portion of Taxiway - East</u> 11" Portland cement concrete 12" Base	1957	
5	<u>Taxiway - Approach End 32</u> 12" Portland cement concrete 18" Crusher run base, CBR 90 4" Pea gravel with perforated 4" drains 40' center to center	1946	
6 and 7	<u>Taxiway - North and South Crosses</u> Incremental 2" asphaltic concrete overlay of the center 36' of taxiway 8" Portland cement concrete 12" Crusher run base, CBR 90 4" Pea gravel with perforated 4" drains, 40' center to center	1946	1972
8	<u>Portion of Taxiway - Far North Cross</u> 12" Portland cement concrete 18" Crusher run base, CBR 90 4" Pea gravel with perforated 4" drains, 40' center to center	1946	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
8A	<u>Portion of Taxiway - Far North Cross</u>		
	7" Reinforced portland cement concrete	1946	
	10" Crusher run base, CBR 90		
	4" Pea gravel with perforated 4" drains, 40' center to center		
9	<u>Taxiway - Approach End 14</u>		
	11" Reinforced portland cement concrete	1951 - 1952	
	16" Base, CBR 60, Plasticity Index 8		
10	<u>Taxiway - Diagonal</u>		
	8" Reinforced portland cement concrete	1946	
	12" Crusher run base, CBR 90		
	4" Pea gravel with perforated 4" drains, 40' center to center		
11	<u>Taxiway - North Cross Extension</u>		
	10" Portland cement concrete	1951	
	14" Crusher run base, CBR 90		
	4" Pea gravel with perforated 6" drains, 40' center to center		
12	<u>Portion of Parking Apron 1</u>		
	Joints resealed (SS-S-167) (as needed)		1966
	11" Reinforced portland cement concrete	1951 - 1952	
	16" Crusher run base, CBR 60, Plasticity Index 8		

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
12A	<u>Portion of Parking Apron 1</u> Joints resealed (SS-S-167) (as needed) 8" Reinforced portland cement concrete 12" Crusher run base , CBR 90 4" Pea gravel with perforated 4" drains, 40' center to center	1946	1966
12B	<u>Portion of Parking Apron 1</u> Joints resealed (SS-S-167) (as needed) 6" Reinforced portland cement concrete on subgrade	1935 - 1941	1966
12C	<u>Portion of Parking Apron 1</u> 10" Portland cement concrete 6" Cement-treated base course 6" Lime-treated subbase Compacted subgrade	1975	
13	<u>Portion of Parking Apron 2</u> Joints resealed (SS-S-167) (as needed) 7" Reinforced portland cement concrete 10" Crusher run base, CBR 90 4" Pea gravel with perforated 4" drains, 40' center to center	1946	1966
14	<u>Portion of Parking Apron 2</u> Joints resealed 9SS-S-167) (as needed) 11" Reinforced portland cement concrete 16" Crusher run base, CBR 60, Plasticity Index 8	1951 - 1952	1966

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
15	<u>Floor Hangar 1 (Not shown on Figure A-1)</u> 6" Reinforced portland cement concrete 6" Gravel	1938	
16	<u>Floor Hangar 2 (Not shown on Figure A-1)</u> 7" Unreinforced portland cement concrete 6" Gravel	1946	
17	<u>Floor Hangar 3 (Not shown on Figure A-1)</u> 7" Unreinforced portland cement concrete 18" Fill sand	1946	
18	<u>Portion of Parking Apron 2</u> 10" Portland cement concrete 12" Base course Compacted subgrade	1964 1964	
19	<u>Portion of Parking Apron 2</u> 11" Portland cement concrete 14" Crushed rock base	1970 1970	
20	<u>Red Label Loading Area</u> 12" Portland cement concrete 10" Subbase	1968 1968	
21	<u>Fuel Lanes</u> 11" Portland cement concrete (Flexplane joints) 16" Crusher run base	1956 1956	

DATE	BY	REVISIONS



NOTE - CONSTRUCTION HISTORY ITEMS 15, 16 AND 17 (HANDS) ARE NOT SHOWN ON THIS DRAWING.

PROJECT NO.	DATE	BY	REVISIONS
USBRAS MOFFETT FIELD CALIF PAVEMENT CONDITION SURVEY CONSTRUCTION HISTORY			
P (*****)			

APPENDIX A, FIGURE A-1

APPENDIX B
CLIMATOLOGICAL DATA

APPENDIX B

CLIMATOLOGICAL DATA FOR
USNAS MOFFETT FIELD, CA

MEAN TEMPERATURE °F

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1949	61.3	47.0	52.5	56.4	59.2	64.4	63.5	63.8	65.3	58.5	56.9	46.5	6.3
1950	44.6	49.6	51.4	57.0	59.0	61.5	65.5	65.3	65.5	61.5	59.9	52.5	57.9
1951	48.6	50.1	52.5	54.1	60.5	62.0	63.3	66.7	64.1	61.1	55.1	47.9	57.0
1952	47.0	50.5	51.0	56.9	61.1	61.3	66.2	64.5	66.8	61.9	52.7	50.1	57.5
1953	52.9	51.2	52.3	55.0	58.0	61.6	65.6	64.8	66.9	60.6	55.9	51.5	58.0
1954	49.3	53.0	51.2	59.2	60.2	63.2	66.3	67.6	62.5	59.4	54.7	47.9	57.5
1955	45.4	48.7	52.8	51.5	59.1	61.3	62.3	63.2	63.1	59.5	53.3	52.1	56.0
1956	50.1	47.6	51.4	54.2	59.4	61.8	63.4	64.0	64.7	58.3	54.6	48.7	56.4
1957	46.2	53.7	54.4	57.6	59.9	65.7	65.6	64.9	65.4	61.3	53.9	49.5	58.1
1958	50.8	56.0	51.4	56.1	61.0	64.3	65.0	67.4	68.3	63.1	54.9	53.9	59.4
1959	52.3	51.5	56.6	59.1	59.3	63.8	65.9	66.1	64.7	64.6	55.9	51.0	59.2
1960	49.4	52.5	56.4	56.5	59.0	66.3	65.1	64.0	64.1	60.6	53.8	49.2	58.1
1961	48.2	53.8	53.2	57.0	56.9	65.3	66.9	66.5	65.0	61.5	54.3	47.9	58.0
1962	49.1	50.6	51.4	58.0	58.4	62.5	62.8	65.5	62.8	61.1	56.9	50.5	57.5
1963	46.1	58.1	53.3	54.6	59.7	62.7	64.5	64.8	67.2	62.2	54.8	46.6	57.9
1964	49.6	52.1	52.5	55.3	56.0	62.1	64.5	65.3	64.6	63.6	53.1	52.2	57.6
1965	50.1	51.6	53.7	56.3	58.5	60.4	63.4	66.3	63.1	63.5	56.1	46.8	57.5
1966	49.7	50.6	54.2	60.4	60.5	64.9	64.2	65.3	65.7	62.8	56.0	49.9	58.7
1967	50.8	52.2	53.2	50.7	60.5	61.6	65.9	67.1	68.2	64.3	58.7	49.8	58.6

TOTAL PRECIPITATION INCHES

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1949	.51	2.19	3.57	.01	.58	T	.13	.11	.06	.18	.79	1.11	9.24
1950	3.42	.63	1.22	.62	.13	T	.03	T	.11	2.19	3.27	3.89	15.51
1951	1.73	1.62	1.23	.56	.61	.09	.00	T	T	.43	1.75	4.13	12.15
1952	5.43	1.07	4.00	1.63	.03	.04	.02	T	.02	.01	1.51	5.20	18.96
1953	1.38	.09	.98	.89	.60	.12	.00	.05	.00	.22	1.48	.34	6.15
1954	1.79	1.02	3.00	.35	.07	.29	.00	T	T	T	1.05	2.98	10.55
1955	3.44	2.35	.12	1.10	.78	.00	T	T	T	T	1.49	9.55	18.83
1956	5.62	1.20	.15	.61	.81	.00	.00	.00	.45	.54	T	.51	9.89
1957	2.64	2.62	1.39	.95	1.52	.05	T	.00	.29	.97	.34	2.57	13.34
1958	3.63	5.99	5.95	3.36	.58	.13	T	.00	.08	.08	.18	.66	20.64
1959	2.73	4.18	.30	.15	.02	.00	.00	T	1.98	T	.01	1.09	10.46
1960	4.14	2.75	.44	.87	.31	.00	T	.00	T	.04	2.98	.84	12.37
1961	1.52	.69	2.25	.71	.82	.05	.00	.07	.23	.10	2.31	1.43	10.18
1962	1.15	5.57	1.73	.12	T	T	.00	T	.01	3.52	.34	1.78	14.22
1963	3.28	2.00	2.49	3.11	.63	.02	T	.02	.14	.85	2.30	.15	14.99
1964	3.27	.16	.97	.03	.45	.46	T	.10	.30	.70	2.88	4.34	13.36
1965	2.20	.59	1.93	2.26	T	T	.02	.19	.01	.06	4.19	2.71	14.16
1966	1.76	.94	.44	.53	.13	.23	.31	.03	.12	.00	2.69	2.68	9.16
1967	5.43	.20	3.36	3.98	.10	.11	.00	.00	.03	.18	1.33	1.57	16.29

APPENDIX C
CONDITION SURVEY PROCEDURES

Appendix C

CONDITION SURVEY PROCEDURES

Step 1. Preliminary Survey

In the preliminary survey the evaluators make a general and personal inspection of all airfield pavement areas, during which they note the type and distribution of defects in each facility (runway, taxiway, etc.). In addition, a previously-prepared construction history is consulted and areas of different construction and different pavement type (AC or PCC) within a facility are noted. As a result of these efforts, each pavement facility is then divided into "discrete areas" of reasonably similar failure modes for performance of the subsequent sampling and tally or measurement of defects. Thus, if the type and/or number of defects found in one portion of a facility are distinctly different from those found in another portion of that facility, discrete areas are selected on this basis. If, however, the pavement facility contains few defects or if the defects found are similar in type and distribution throughout the facility, each facility is individually divided for survey according to the construction history. Under either criterion, a discrete area may vary, for example, from a 500 foot length of runway or taxiway to the entire length of the facility. All discrete areas are numbered with a system that relates the discrete area to the runway, taxiway, etc., of which it is a part. For example, discrete areas comprising Runway 11-29 are designated R 11-1 and R 11-2, etc.; discrete areas for Taxiway 2 are T 2-1 and T 2-2, etc.

A special survey of singular occurrences of serious defects is made during the preliminary survey. This is necessary because the statistical sampling techniques utilized in the subsequent survey are effective in spotting defects only when such defects are numerous and/or relatively well distributed. This abbreviated special survey provides information on those infrequent defects, if any, which may present a problem to safe aircraft operation.

Step 2. Statistical Sampling and Defect Survey

After discrete areas are selected, a number of small "sample areas" are chosen within each discrete area. The total number of sample areas is determined by statistical theory as a function of the relative size of the discrete area. Actual locations of the sample areas are selected at random from the discrete area.

Sample areas in PCC pavements basically consist of individual slabs, usually $12\frac{1}{2}$ x 15 feet in size. For the convenience of the evaluators, either a single slab or a number of adjacent slabs can be considered as a sample area. Both types of sampling area are shown schematically in Figure C-1. Note from Figure C-1 that individual sample slabs and/or sample strips are selected within the center 100 feet (laterally) of runways and within the center 50 feet (laterally) of taxiways by a random selection process. For parking aprons, mats, etc., similar sample areas are selected at random over the entire pavement area.

For AC pavements, sample areas are fifty-foot-square areas located as shown in Figure C-2. For parking aprons, mats, etc. (not shown in Figure C-2) sample areas are fifty-foot square, as for other traffic areas, and randomly located over the entire pavement area.

All defects or defected slabs in each of the selected sample areas are noted on appropriate data sheets. For PCC pavement slabs or sample strips, either single or multiple occurrences of a given defect type within the slab qualify the slab as a defected slab. For example, one or more spalls qualifies a slab as a spalled slab. A crack in the same slab requires that it be counted again, this time as a cracked slab. No measurement of length, area, etc. is recorded for PCC pavement defects. When a sample slab strip is chosen for test, the above mentioned tally method (slab by slab) is still utilized.

The defects found in AC sample areas are measured and tallied, rather than merely tallied as are those for PCC pavements. Depending on the type of defect, the total length in feet (for cracks, etc.) or total area in square feet (for pattern cracking, raveling, etc.) is recorded.

The above survey of defects found in sample areas (in each discrete area) are shown in column (c) of the Discrete Area Defect Summary sheets, Figures C-3 and C-4. Separate summary sheets are provided for portland cement concrete (PCC) and asphaltic concrete (AC) pavements. Total defect counts for the entire discrete area are calculated by a linear extrapolation of the defect data in column (c), and are shown in column (d) of the Discrete Area Defect Summary sheets. To remove the influence of the size of the discrete area on the total defect count (i.e., the bigger the area, the larger the defect count), the total defect count is divided by either the number of slabs in the discrete area (for PCC pavements) or by the area (in 10-square-foot increments) of the discrete area (for AC pavements). This gives a defect density (per slab or per 10 square feet) which is listed in column (e).

Step 3. Defect Severity Weighting System

A weighting system, providing a numerical weight for each type defect in proportion to the relative severity of that defect, is applied in the following manner to each of the defect counts in the discrete area;

given defect density x weight for that type defect = weighted defect density

This is accomplished in columns (f) and (g) of the discrete Area Defect Summary sheets. Next, a total weighted defect density is obtained for each discrete area by summing column (g) of these sheets. Note that a letter suffix is added to each total weighted defect density for the purpose of further distinguishing between asphaltic concrete defect densities (suffix "A") and portland cement concrete defect densities (suffix "C").

The defect weighting guide developed by NCEL assigns greater weights to defects that (1) presently affect the safe operation of aircraft or the cost of aircraft operation; (2) will lead to increased airfield pavement maintenance costs; or (3) will result in significant deterioration of load-carrying capacity of the pavements. The resultant numerical weights are further modified to reflect variations in pavement environment from station to station. For example, higher (more severe) weights are assigned to defects which are affected by factors such as freezing weather, heavy rainfall, or blow sand for surveys of airfields located in areas where these undesirable environmental effects occur. Thus, it can be seen that the higher the numerical weighted defect density, the poorer the condition of the surveyed pavement.

Remarks concerning the general pavement condition and the defects identified are given in narrative form on each Discrete Area Summary sheet. In addition, photographs of typical pavement conditions noted during the survey are used to further illustrate typical pavement defects.

Step 4. Facility Summary--Weighted Defect Densities

A final step in providing a numerical condition rating for each facility (runway, taxiway, etc.) is accomplished in the Facility Defect Summary sheets, Figures C-5 and C-6. Again note that separate sheets have been provided for AC and PCC pavements. In these sheets the individual weighted defect densities for all discrete areas comprising the entire AC or PCC portion of a facility (runway, taxiway, etc.) are summarized in column (a). When an AC or PCC facility (or portion) has been divided into more than one discrete area for the condition survey, the proportional contribution of each discrete area to the entire AC or PCC facility area is determined in column (b). In column (c) these proportions are applied to the individual discrete area weighted defect densities listed in column (a) and added to obtain an overall average weighted defect density for the entire AC or PCC portion of the facility (marked "total" in column (c)). When an entire AC or PCC

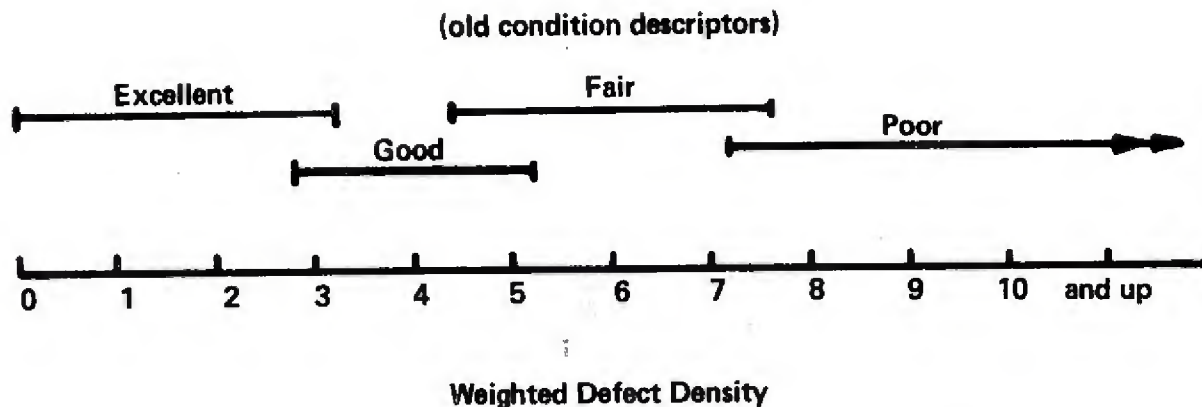
facility (or portion) has been designated a single discrete area (as often occurs), the proportionality factor in column (b) is obviously 1.00 and the discrete area weighted defect density from column (a) becomes the average weighted defect density for the entire facility (or portion) in column (c).

GENERAL COMMENTS ON CONDITION SURVEY PROGRAM

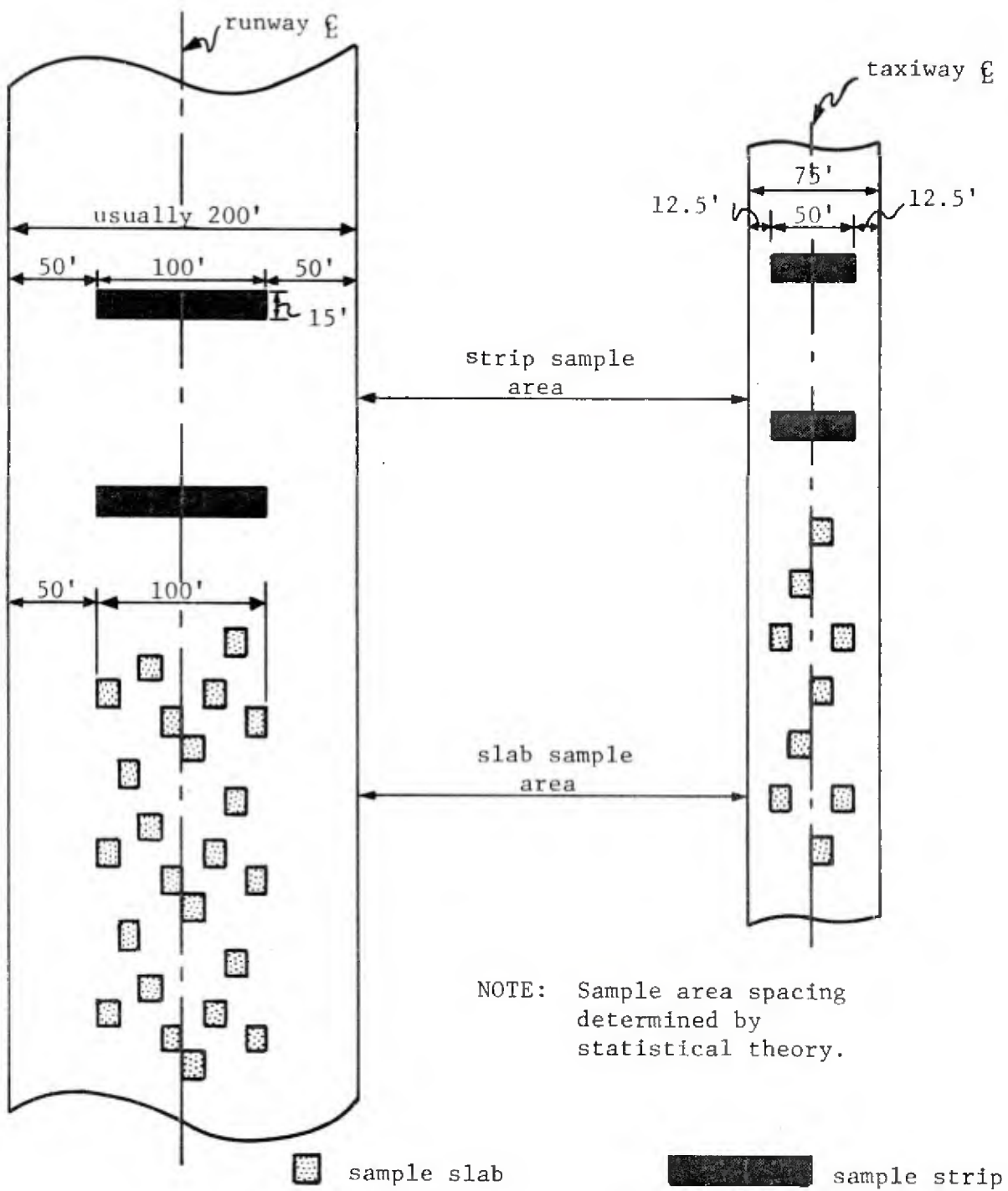
The weighted defect densities, listed in column (a) of the Facility Defect Summary for individual discrete pavement areas and in column (c) as averaged weighted defect densities for entire AC or PCC runways, taxiways, etc. (or portions thereof) represent, numerically, the surface condition of the airfield pavements at the station. As previously stated, the larger defect density numbers indicate basically a greater number and/or severity of defects per unit area of pavement, i.e., a poorer pavement. Thus, they represent the final product of the pavement condition survey. It should be noted specifically, however, that AC and PCC pavement defect densities, although often numerically similar, are obtained by two different condition survey techniques and, as such, are not numerically compatible and must not be combined. (It is largely because of this fact that the letter suffixes "A" and "C" have been affixed to defect densities for AC and PCC pavements respectively.) As an example, consider the common case of an AC runway with PCC ends. The condition survey system presented herein provides individual discrete are weighted defect densities for discrete areas selected on both AC and PCC pavements, but provides a separate average weighted defect density for the entire AC portion and a separate average weighted defect density for the combined PCC end pavements. It is not possible to combine these defect densities to obtain an averaged AC/PCC defect density for the entire runway. Thus the defect densities for AC and PCC are reported separately, given different letter suffixes, and should include the letter suffix when reference is made to them.

Individual numerical defect densities, however accurately they indicate pavement condition, may mean little to the reader of an individual airfield condition survey report, for he has no basis upon which to judge the relative severity of pavement condition associated with the numbers obtained for his pavements. The primary value of a numerical condition survey program will be the accumulation of uniformly-obtained, comparative condition data for many airfields which can best be correlated, studied, and used in the decision-making processes at headquarters levels.

For the benefit of the individual reader, however, an effort was made during the first year of pavement condition surveys (FY-70) to relate the numerical condition (defect densities) to the basic subjective condition descriptors (excellent, good, fair, poor, etc.) used in all previous Navy pavement evaluation procedures. Although the subjective condition-descriptor approach is poorly regarded as a means of comparing pavement condition from one airfield to another, the following diagram may serve temporarily as a rudimentary bridge between the old subjective system and the new (numerical) condition approach:



The system of numerical defect densities was developed to aid in determining the suitability of airfield pavement surfaces for satisfying aircraft operational requirements and to establish an unbiased, uniform basis for initiating maintenance and repair efforts. As such, defect densities are simply visually-determined indicators of the condition of the pavement and do not represent true "condition ratings" in that they do not include factors relating to pavement strengths, traffic usage, etc. It is possible that additional measurements or modifications may be considered necessary or desirable in future condition survey programs.



Typical Runway

Typical Taxiway

Figure C-1 Portland cement concrete sample areas.

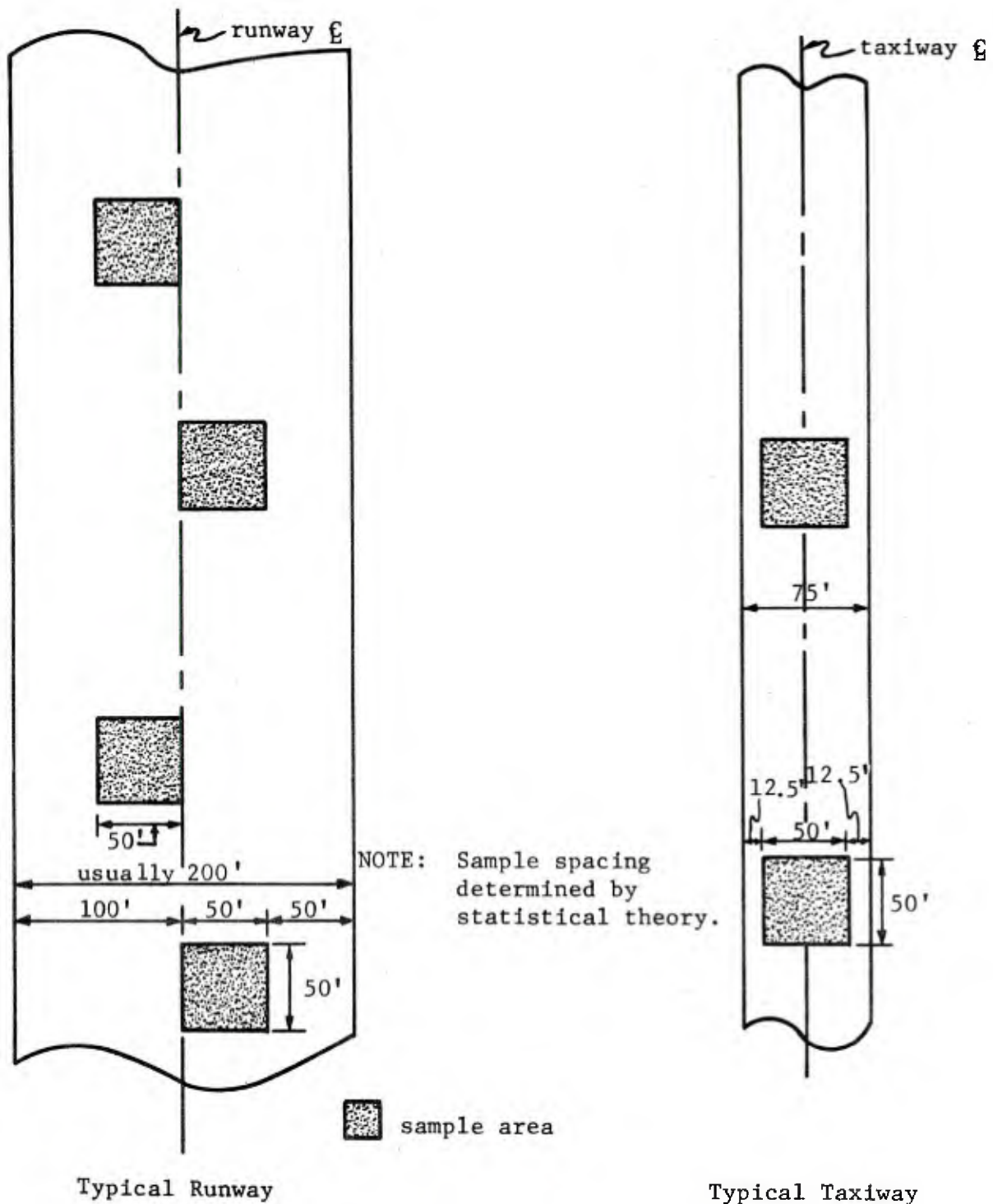


Figure C-2 Asphaltic concrete sample areas.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield EXAMPLE Facility Taxiway 2
 Discrete Area T2-1 Area of Discrete Area (a) 97,700 ft²
 No. of Sample Areas (b) 10 Ratio: (a/2500b) 3.9

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	80 ft	312 ft	0.0319	2.5	0.0798
Reflection Crack					
Faulting					
Patching					
Settlement or Depression	530 ft ²	2,067 ft ²	0.2116	9.0	1.9041
Pattern Cracking	126 ft ²	491.4 ft ²	0.0503	2.5	0.1257
Rutting					
Reveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
Total					2.11 A**

Remarks on Pavement Condition

The depressions were generally 1/2" deep. Pattern cracking formed 6" to 12" polygons and was associated with the depressions. Longitudinal cracks were unsealed and 1/8" wide. (See Figure 5.)

* Transverse crack, longitudinal crack, and longitudinal construction joint
 ** Letter suffix "A" indicates asphaltic concrete pavement

Figure C-3. Typical Asphaltic Concrete Discrete Area Defect Summary

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield EXAMPLE Facility Taxiway 2
 Discrete Area T2-2 Total Slabs in Discrete Area (a) 1,542
 No. of Slabs Sampled (b) 193 Ratio a/b = 8.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break	1	8	0.0052	2.5	0.013
L.C. or T.C. *	19	152	0.0985	1.0	0.098
I.C. **	1	8	0.0052	2.5	0.013
Depression		2***	0.0013	9.0	0.012
Spalling	59	472	0.3060	7.5	2.295
Scaling					
Disintegrated Slab					
Joint Seal	10	80	0.0518	2.5	0.130
Pumping					

Total **2.57 C*****

Remarks on Pavement Condition

Spalls were generally 1" wide by 3" long with some spalls up to 4" wide and 12" long. The longitudinal cracks found were mostly sealed. The depressions noted as singular defects consisted of two depressed and cracked slabs. The depression was approximately 1/2" deep. An attempt had been made to repair these slabs with portland cement concrete. Joint seal was missing in strips 4" to 12" long. (See Figures 25 and 26.)

- * Longitudinal crack or transverse crack
- ** Intersecting crack
- *** Counted as singular defects during the preliminary survey
- **** Letter suffix "C" indicates portland cement concrete pavement

Figure C-4. Typical Portland Cement Concrete Discrete Area Defect Summary

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY Airfield <u>EXAMPLE</u> Date Surveyed _____			
Facility (or portion)	Weighted Defect Density Total	Ratio: $\frac{\text{Discrete Area}}{\text{Total Facility Area}^*}$	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Taxiway 2 T2-1	2.11 A	1.00	2.11 A
Taxiway 10 T10-2	0.004 A	1.00	0.004 A
Towway 1 TOW-1	3.77 A	1.00	3.77 A
Parking Apron 2 PA2-1	7.29 A	1.00	7.29 A
Parking Apron 6 PA6-1	7.44 A	1.00	7.44 A
Parking Apron 7 PA7-1	4.97 A	0.79	3.93
PA7-2	23.18 A	0.21	4.87
			<u>8.80 A (Total)</u>
Parking Apron 8 PA8-1	2.76 A	1.00	2.76 A
Central Mat CM-1	2.89 A	1.00	2.89 A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

Figure C-5. Typical Asphaltic Concrete Facility Defect Summary

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY Airfield <u>EXAMPLE</u> Date Surveyed _____			
Facility (or portion)	Weighted Defect Density Total	Ratio: $\frac{\text{Discrete Area}}{\text{Total Facility Area}^*}$	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 11-29			
R11-1	0.80 C	0.25	0.02
R11-2	4.43 C	0.75	3.33
			<u>3.35 C (Total)</u>
Runway 18-36			
R18-1	1.25 C	0.68	0.85
R18-2	0.76 C	0.32	0.28
			<u>1.13 C (Total)</u>
Taxiway 1			
T1-1	2.82 C	0.12	0.34
T1-2	0.98 C	0.88	0.86
			<u>1.20 C (Total)</u>
Taxiway 2			
T2-2	2.57 C	1.00	2.57 C
Taxiway 3			
T3-1	1.82 C	1.00	1.82 C
Taxiway 4			
T4-1	3.02 C	1.00	3.02 C
Taxiway 5			
T5-1	0.98 C	1.00	0.98 C
Taxiway 6 and Taxiway 7			
T6-1 and T7-1	0.06 C	1.00	0.06 C

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

Figure C-6. Typical Portland Cement Concrete Facility Defect Summary

APPENDIX D
MU-METER TEST RESULTS

APPENDIX D
 MU-METER TEST RESULTS
 USNAS MOFFETT FIELD, CALIFORNIA

Test Location Run #	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 14R-32L					
Test Section A					
1	14	1.51	0.22	0.46	0.02
2	32	2.87	0.12	0.44	0.02
3	14	4.58	0.20	0.36	0.03
4	32	6.88	0.35	0.70	0.03
5	14	8.65	0.28	0.58	0.04
6	32	13.95	0.54	0.67	0.10
7	14	19.45	0.38	0.63	0.12
8	32	24.11	0.63	0.67	0.52
9	14	27.41	0.58	0.70	0.34
Test Section B					
1	14	1.47	0.18	0.36	0.03
2	32	2.87	0.15	0.38	0.02
3	14	15.36	0.56	0.64	0.41
4	32	16.45	0.42	0.56	0.26
5	14	19.37	0.59	0.65	0.48
6	32	23.69	0.48	0.64	0.04
7	14	27.60	0.62	0.69	0.49
Test Section C					
1	14	1.50	0.38	0.64	0.04
2	32	3.58	0.53	0.60	0.08
3	14	5.70	0.57	0.64	0.28
4	32	12.63	0.65	0.69	0.48
Test Section D					
1	14	1.42	0.22	0.58	0.02
2	32	3.30	0.26	0.54	0.02
3	14	4.89	0.33	0.68	0.02
4	32	8.80	0.34	0.61	0.02
5	14	15.63	0.42	0.66	0.17
6	32	20.02	0.38	0.62	0.17
7	14	30.70	0.48	0.72	0.30
8	32	33.06	0.50	0.65	0.34

APPENDIX D
 MU-METER TEST RESULTS
 USNAS MOFFETT FIELD, CALIFORNIA

Test Location Run #	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 14L-32R					
Test Section A					
1	14	1.44	0.51	0.75	0.04
2	32	3.01	0.55	0.73	0.12
3	14	5.06	0.60	0.73	0.03
4	32	7.00	0.68	0.76	0.54
5	14	13.66	0.68	0.75	0.05
Test Section B					
1	14	1.34	0.30	0.54	0.02
2	32	3.41	0.35	0.55	0.02
3	14	5.18	0.41	0.54	0.03
4	32	9.13	0.46	0.60	0.05
5	14	15.58	0.61	0.70	0.36
6	32	21.04	0.50	0.62	0.18
7	14	26.05	0.61	0.71	0.28
8	32	30.08	0.59	0.66	0.48
Test Section C					
1	14	1.48	0.29	0.50	0.03
2	32	3.05	0.29	0.57	0.08
3	14	4.87	0.50	0.68	0.25
4	32	6.64	0.54	0.66	0.30
5	14	13.76	0.57	0.67	0.26
6	32	21.71	0.58	0.66	0.44
7	14	29.09	0.60	0.67	0.53
Test Section D					
1	14	1.43	0.25	0.40	0.04
2	32	3.01	0.38	0.66	0.03
3	14	4.66	0.51	0.62	0.29
4	32	6.53	0.53	0.70	0.29
5	14	10.43	0.66	0.74	0.48
6	32	14.40	0.68	0.76	0.48
7	14	19.40	0.67	0.72	0.60
8	32	28.86	0.60	0.67	0.52

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