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**STUDY OF EFFECTS OF GROOVING ON
PAVEMENT DETERIORATION
INSPECTION OF GROOVED AIRFIELD
PAVEMENTS**

I. Narrow

**Department of the Army
Ohio River Division Laboratories, Corps of Engineers
and
Construction Engineering Research Laboratory**



TECHNICAL REPORT NO. AFWL-TR-69-166

May 1970

**AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base
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STUDY OF EFFECTS OF GROOVING ON
PAVEMENT DETERIORATION
INSPECTION OF GROOVED AIRFIELD PAVEMENTS

I. Narrow
Department of the Army

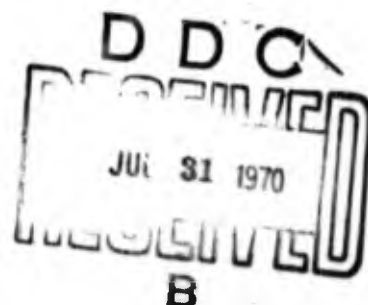
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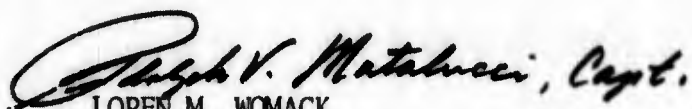
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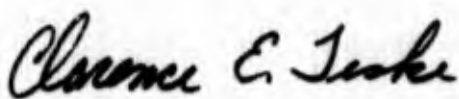
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Inclusive dates of research were January 1969 through December 1969. The report was submitted 13 March 1970 by the Air Force Weapons Laboratory Project Officer, Mr. Loren M. Womack (WLCT).

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This technical report has been reviewed and is approved.


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ABSTRACT

(Distribution Limitation Statement No. 2)

A study was made on the deterioration effects of deliberate grooving on airfield pavements. Grooving is done to reduce hydroplaning and skidding. Grooved pavements were inspected at four civilian and one military airfield. The inspection included portland cement concrete (PCC) runways at four airfields and asphaltic concrete (AC) runways at two airfields, all of which had been grooved within 2 years before the inspection. Grooves in all PCC runways were in excellent condition with no evidence of deterioration except in one case where numerous small popouts and weatherouts have occurred. Grooving had apparently contributed to an increase in these defects. The AC runways showed minor groove deterioration in some areas, and some obliteration of the grooves in one touchdown area. Rubber deposits in grooves have occurred in both PCC and AC pavements, but no removal of the rubber has been required. Grooving has not at present resulted in any significant deterioration of either PCC or AC runway pavements. Some closing of grooves in touchdown areas of AC surfaces can be expected, but this is not considered to be actual pavement deterioration. Where PCC pavements have previous popouts or other surface defects, grooving can be expected to increase these defects. PCC and AC runway pavements should continue to be inspected periodically to determine the long-time effects of grooving.

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SECTION I

INTRODUCTION

1. BACKGROUND

Pavement grooving as a means of eliminating hydroplaning and improving skid resistance of airfield pavements has received considerable attention in this country during the past few years. Extensive studies have been conducted by the National Aeronautics and Space Administration and full scale grooving of airfield runways has been accomplished at a number of commercial and military airfields in this country (Ref. 1). The Federal Aviation Administration initiated an environmental test program on pavement grooving at five airfields with a wide range in weather conditions, and a preliminary report on this study has been issued (Ref. 2). The studies conducted and the field experiences have indicated that the pavement grooving is highly effective in improving aircraft control under adverse weather conditions. However, since most of the runway grooving has been accomplished within the past 2 years, information regarding the effects of the grooving in contributing to pavement deterioration is very limited. A survey of pavement grooving operations accomplished in the United States has been conducted by the Ohio River Division Laboratories and the report (Ref. 3) describes the grooving details and provides a basis for future evaluation of the effects of the grooving on deterioration of the pavements. In view of the current interest in pavement grooving by various Air Force Agencies, an inspection of the grooved airfield pavements to provide an indication of the present pavement performance was considered desirable.

2. PURPOSE AND SCOPE

The purpose of this study was to inspect the condition of the grooved pavements at a number of airfields in the United States in order to evaluate the effects of the grooving on deterioration of the pavement surface.

The scope of this study was limited to an inspection of the grooved runway pavements at four commercial airfields and one military airfield. This report presents the results of the inspections made, and pertinent comments on performance of the grooved pavements based on the field observations and discussions with airfield personnel.

SECTION II
PAVEMENT INSPECTIONS

1. KANSAS CITY MUNICIPAL AIRPORT

a. Runway Grooving

The grooving at the Kansas City Airport is limited to a portion of Runway 18/36 and includes both rigid and flexible pavements. This runway is 7000 feet long by 150 feet wide PCC pavement with an AC overlay beginning near the center of the runway and extending southward approximately 2000 feet toward the 36 end. The grooved portion of the runway is 4500 feet long and 130 feet wide with 10 feet of pavement on each side left ungrooved. Six hundred feet of pavement at the south end of the runway and 1900 feet at the north end were not grooved. The AC overlay is approximately in the center of the grooved portion of the runway. All grooves were sawed transverse to the runway centerline, and are 1/8-inch wide by 1/4-inch deep at a spacing of 1 inch center to center. The grooving was completed in May 1967.

b. Discussion with Airport Personnel

In discussions of the grooving operations with airport personnel, they indicated that, prior to grooving, there was much concern about the effectiveness of grooving and possible pavement deterioration. They now feel that the grooving has been very effective from an operational standpoint, and that the effect on pavement deterioration has been negligible. A wider spacing of grooves than that used is considered preferable, and they stated that the spacing should be at least 1 inch between groove edges. The groove section used was considered satisfactory and there has been no problem with rubber accumulation in the grooves. A minor problem was experienced with dust from dried cutting waste. The slurry was not thoroughly flushed from the pavement immediately after sawing and resulted in dusting under traffic.

c. Pavement Inspection

The pavement inspection was made on 20 March 1969. Because of the heavy flying schedule with only one runway in operation, it was not possible to make a continuous inspection of the grooved pavement. However, access to the runway was permitted for brief examinations of the grooving and for taking

photographs in several different locations. The condition of the grooved pavement is shown in figures 1 to 12 inclusive, and comments on the conditions observed follow.

(1) AC Grooving

The condition of the grooved AC overlay pavement is illustrated by figures 1 and 2 at the north end and by figure 3 at the south end of the overlay. The random crack shown in figure 2 is not related to the grooving. There is some evidence of small areas of minor surface raveling which occurred during sawing of the grooves. A close view of this condition is shown in figure 4. Some closing of the grooves was observed in center lanes near the north end of the overlay as shown in figure 5. A close view of this groove closing is shown in figure 6.

The overall condition of the grooved AC overlay pavement is considered to be very good. Only a minor amount of deterioration has developed after about 2 years of service under heavy traffic conditions. There was no explanation for the closing of the grooves which has occurred in one area. Since this area is near the juncture with the PCC pavement, it is possible that the AC overlay is featheredged in a thin layer over the PC concrete and would be more subject to compaction under traffic. Also, this closing appears to be in an area where lift-off occurs, and the impingement of jet exhaust during lift-off could be a factor. However, the closing of the grooves has not resulted in any surface spalling or raveling, and it is not considered to be a pavement deterioration. No maintenance of the grooved AC pavement has been required.

(2) PCC Grooving

Figures 7 and 8 show the pavement grooving near the south end of the runway and figure 10 shows the grooving near the juncture of this pavement section with the AC overlay pavement. Figure 9 is a close view of the grooving in the same area as figure 8. Close views of minor defects in the pavement surface are shown in figures 11 and 12.

The grooves in the PCC pavement are in excellent condition with no evidence of any raveling or deterioration at groove edges. Numerous small holes are present in the pavement surface which are due mainly to weathering out of poor quality materials. Based on their darkened appearance, it is believed that most of these defects were present before the grooving was accomplished. This condition can be seen in figures 7, 8, and 9. However, many of the spalls

in some areas appear to be recent (see figures 10 and 11) and the grooving may have contributed to this spalling. Most of these spalls are quite small, and they have not been repaired nor considered to be a problem at this airfield. Figure 12 shows an overlapping of the grooving which can result in surface deterioration. This condition can be avoided by proper spacing of the sawing equipment during the grooving operation.

d. Summary

The grooving both in the PCC and AC pavements is in good condition, and no maintenance of the grooved pavements has been required.

The PCC pavement has numerous small surface voids and spalls, some of which appear to have developed recently. It is probable that the grooving has contributed to some of these surface defects.

The AC grooving generally is in very good condition. Some closing of the grooves was evident in the center lanes at the north end of the AC overlay, but this has not resulted in any deterioration of the pavement.

2. CHICAGO MIDWAY AIRPORT

a. Runway Grooving

Runways 13R/31L and 4R/22L at Midway Airport were resurfaced with continuously reinforced PCC pavement in November 1967. Because of a slippery condition, both runways were grooved during the period from July to September 1968. Runway 13R/31L is 6520 feet long and Runway 4R/22L is 6104 feet long. Each runway consists of a 100-foot wide continuously reinforced PCC pavement with a 37-1/2-foot AC shoulder on each side. The PCC overlays are 8 inches thick and each runway was constructed in four 25-foot lanes. Both runways were grooved transversely across the 100-foot PCC pavement and 2 feet into the AC shoulder on each side for a total width of 104 feet. The grooves are 1/4-inch wide by 1/4-inch deep with a spacing of 1-1/4 inches center to center.

b. Discussion with Airport Personnel

Airport personnel stated that the grooving has been very effective from an operational point of view. The grooved areas were thoroughly flushed with water under high pressure immediately after grooving until all cutting waste was removed, and there has been no problem with dust from sawing operations. There has been very little accumulation of rubber in grooves and no rubber removal has been required. Also, sand used with de-icing materials has not

accumulated in the grooves. There appears to be a self-cleaning action from aircraft operations which keeps the grooves clean. The only problem that has been encountered is extensive spalling along the center longitudinal joints. This is a structural problem and is not related to the grooving. No joint plans were available, but it was stated that the centerline joint was a keyed joint without reinforcement or dowels. This would provide a weak condition for a continuously reinforced pavement. Repairs have consisted of removal of the spalled concrete and patching with a bituminous mixture.

c. Pavement Inspection

The inspection of Runway 13R/31L was made on 1 April 1969. The other grooved runway, 4R/22L, was not examined as it was being used for flight operations. It was stated that the two runways are in essentially the same condition, and the results of observations made apply equally to both runways.

All of the pavement grooving was in excellent condition. Touchdown areas showed tire marks but there was very little evidence of rubber deposits. It is probable that some of the tire marks were present when the pavement was grooved. Other areas were free of surface marks and there was no evidence of any groove deterioration or other surface defects. The continuously reinforced pavement had typical transverse cracks at closely spaced intervals, but there was little evidence of deterioration at intersections of the grooves with the cracks. The only pavement defect observed was a large amount of spalling along the west side of the center longitudinal joint. There was no spalling along the other two longitudinal joints of the PCC pavement. Typical views of the grooved runway pavement are shown in figures 13 to 18 and a description of the condition observed follows:

(1) Figure 13 shows the grooving in the touchdown area near the 31L end (SE end) of the runway. The pavement surface is discolored from landing operations, but there is very little rubber deposited in the grooves. The grooves are sharply outlined and the grooved pavement is in excellent condition. This is also evident in figures 14 to 18.

(2) Figure 14 shows another view in the same general area as figure 13. The outside lane in foreground shows less discoloration from traffic. The transverse cracks are typical for continuously reinforced pavements.

(3) Figure 15 shows the spalling along the center longitudinal joint near the 31L end of the runway. This spalling has occurred recently and has not been repaired.

(4) Figure 16 shows the bituminous patching of the spalled center longitudinal joint near the center of the runway.

(5) Figure 17 shows the grooving at a random transverse crack in the continuously reinforced pavement. The cracks are very fine and there is very little raveling or deterioration at the intersection of the grooves with the cracks.

(6) Figure 18 is a close view of the same crack shown in figure 17. The slight raveling probably occurred during the sawing adjacent to the existing crack and there is no evidence of new deterioration.

d. Summary

Pavement grooving at Midway Airport was accomplished during the summer of 1968 and has had less than 1 year of use with one winter exposure period. The grooving in Runway 13R/31L was in excellent condition with no evidence of pavement deterioration due to the grooving. Runway 4R/22L was not inspected but is assumed to be in equally good condition based reports by airport personnel.

Extensive spalling has occurred along longitudinal joints of the two continuously reinforced concrete runways. This is a structural problem which is not related to the pavement grooving. However, this condition would warrant further study in connection with any proposed use of continuously reinforced pavements for military airfields.

3. J. F. KENNEDY INTERNATIONAL AIRPORT

a. Runway Grooving

Grooving of Runway 4R/22L at Kennedy International Airport was accomplished during the period from May to August 1967. This runway is 8400 feet long by 150 feet wide, and was grooved transversely over the full length to a width of 140 feet. A 5-foot width of pavement on each side was left ungrooved for turning of grooving equipment. The grooves are 1/8-inch deep and are V-shaped with a top width of 3/8 inch and rounded bottom. The grooves were sawed at a spacing of 1-3/8 inches with 1 inch clear distance between groove edges. This groove pattern was used because it was considered that eliminating sharp groove edges would reduce deterioration of the grooves due to traffic and weathering.

b. Discussion with Airport Personnel

Airport personnel stated that pilot comments have been very favorable and that the grooving is considered to be highly successful from an operational viewpoint. Based on present performance, New York Port Authority is contemplating additional grooving at Kennedy International Airport as well as at LaGuardia and Newark Airports. Although rubber deposits tend to accumulate in the grooves, this has not been a problem. It was indicated that the rubber deposited is comparatively soft and not the vulcanized type that is generally deposited on the pavement surface. The grooves tend to be self-cleaning, but the Port Authority has plans to remove the rubber deposits if necessary. Port personnel have observed no pavement deterioration and no repairs have been necessary.

c. Pavement Inspection

The inspection of the grooved runway 4R/22L was made on 10 April 1969. The runway was being used for very active flying operations and only brief examinations could be made in different areas. The inspection was started near the 4R end of the runway and the general surface condition was observed while driving slowly over the pavement. A number of stops were made for close examination of the pavement and for taking photographs. Several small areas of ungrooved pavement were observed where the grooving equipment had skipped over low places in the pavement surface. There was appreciable rubber deposited in grooves in the touchdown area. This rubber was comparatively soft and could be readily scraped out with a knife blade. The runway grooving was in excellent condition and there were no evidences of groove deterioration or surface defects due to the grooving.

An examination also was made of an FAA experimental test installation in a taxiway pavement. This is part of environmental test program and includes a variety of groove patterns. There has been essentially no traffic on this taxiway and all grooved sections were in excellent condition.

Typical views of the grooved pavements are shown in figures 19 to 22, with comments thereon as follows:

(1) Figure 19 is a typical view of the grooving in Runway 4R/22L pavement showing the excellent condition of the pavement surface and grooves. There is no evidence of any surface deterioration, and there is very little rubber deposit in the grooves in this location.

(2) Figure 20 shows a close view of the grooving in the same general areas as figure 19.

(3) Figure 21 shows a small ungrooved area which was skipped during grooving due to a low place in the pavement surface. This is a deficiency in the grooving and not a pavement deterioration.

(4) Figure 22 shows a grooving test section in the taxiway pavement used for the FAA environmental test program.

d. Summary

After nearly 2 years in service the grooving in Runway 4R/22L is in excellent condition, and there is no evidence of any groove deterioration or pavement defects due to the grooving.

There is appreciable rubber deposit in grooves in touchdown areas, but this has not been considered a problem for operations and rubber removal has not been considered necessary.

All groove patterns used in the FAA environmental test installation were in excellent condition and have shown no adverse effects from weathering.

4. WASHINGTON NATIONAL AIRPORT

a. Runway Grooving

Runway 18/36 at Washington National Airport, which was grooved in March-April 1967, was the first operational runway to be grooved in the United States. The original runway constructed in the early 1940's consisted of a flexible pavement up to 6 inches in thickness. An overlay pavement consisting of a 3-inch to 9-inch thick wearing surface of asphaltic concrete was placed in the spring of 1965. The overlay was constructed by two separate contractors, each using his own source of aggregate. The runway is 6870 feet long by 150 feet wide and the entire pavement surface was grooved transversely to the runway centerline. The grooves were sawed 1/8-inch wide by 1/8-inch deep at a spacing of 1 inch center to center.

b. Discussion with Airport Personnel

An inspection by FAA in August 1968, after about 17 months of service, indicated that there had been no appreciable groove deterioration. The grooves had not collapsed, and they had not become filled with rubber, sand or sealcoat material. There had been a minor amount of damage caused by snow-plow operations.

In the fall of 1968, a shifting of a portion of the surface in the touchdown area of Runway 36 was noted. The shift is noticeable because of a distortion of the pavement grooves in this area. There appears to be some increase in shift areas with time. A recent inspection in March 1969 indicated minor deterioration of the grooves in the form of chipping or raveling of fine aggregate particles at the groove edges. This was evident mainly near the south end of the runway. No maintenance of the grooves has been performed.

c. Pavement Inspection

The runway pavement was inspected on 10 April 1969 between 0600 and 0700 hours when jet aircraft operations are restricted. The flying schedule during the inspection was very light and considerable time was spent walking over the grooved area. Pertinent comments on the conditions observed during the pavement inspection follow:

(1) The grooves in touchdown areas have become filled with rubber deposits to about 40 to 60 percent of the saw-cut depth. Grooves in other areas are essentially free of rubber deposits.

(2) Minor raveling or chipping of fine aggregate particles was observed. In non-touchdown areas this condition was evidenced by the white appearance of exposed fine aggregate particles. In touchdown areas the surfaces were covered with rubber deposits and were not very noticeable.

(3) Edges of the grooves in the touchdown areas appeared to be slightly rounded off.

(4) Slight raveling is occurring along longitudinal paving joints. This condition appears to be aggravated by the grooving as evidenced by branching out of the ravel areas at the grooves.

(5) Grooves in the touchdown area near the south end of the runway are curved or distorted because of a shifting of the asphalt wearing surface.

(6) No major deterioration of the pavement was observed in any area and the grooves appeared to be in good condition.

d. Photographs of Grooved Pavement

Figures 23 to 28 illustrate the condition of the grooved pavement, and are described as follows:

(1) Figure 23 shows a general view of the grooved pavement in the touchdown area about 1200 feet from the south end of the runway. The grooving is in excellent condition and there is only a moderate amount of rubber deposit in the grooves.

(2) Figure 24 shows the shifting of the pavement in the touchdown area in the same general location as figure 23. The grooving is not deteriorated in the shifted area indicating that the movement is at some depth below the surface and is not due to the grooving.

(3) Figure 25 shows a close view of the rough-textured AC pavement surface. No deterioration is evident.

(4) Figure 26 shows an ungrooved area which was skipped during grooving due to a depression in the surface.

(5) Figure 27 shows a close view of the rubber deposit in grooved pavement.

(6) Figure 28 shows minor deterioration at intersection of grooving with crack in pavement.

e. Summary

In general, the grooved AC runway pavement at Washington National Airport is in good condition with only slight deterioration in the form of minor raveling and slight rounding-off of groove edges.

Some filling of grooves with rubber deposits is occurring in touchdown areas, but this has not required any removal and is not considered to be a pavement deterioration.

5. BEALE AFB, CALIFORNIA

a. Runway Grooving

Grooving of the runway at Beale AFB was accomplished during the period from October 1967 to February 1968. The runway is 300 feet wide by 12,000 feet long and the PCC pavement ranges from 18 to 24 inches in thickness. The grooved area is 140 feet wide by 10,800 feet long with 600 feet at each end and 80 feet on each side left ungrooved. The grooves are 1/4-inch deep at a spacing of 1 inch center to center, and the grooving is transverse to the runway centerline.

b. Discussion with Base Engineer Personnel

Base personnel stated that the grooved pavement is in excellent condition and there has been no evidence of any surface deterioration. The grooving has been very effective for operations, and it was stated that during wet weather, the grooved portion of the runway appears dry while the adjacent ungrooved portion appears to have a layer of water on the surface. Weather conditions in the area are mild and very little freezing weather is experienced. Rubber deposited in grooves has not been a problem but they expect that rubber removal will have to be accomplished periodically. A chemical solvent is used for this rubber removal. Some difficulty was encountered initially in grooving due to inadequacy of the equipment used by the contractor. Different equipment was provided which had sufficient power to accomplish the grooving.

c. Pavement Inspection

The grooved runway was inspected on 18 June 1969, about 16 months after the grooving had been completed. The pavement surface was in excellent condition and there was no evidence of any deterioration of the pavement due to the grooving. There were very few surface blemishes and the grooved pavement appeared to be in the same condition as the ungrooved portion of the runway. A small amount of rubber deposit was observed in grooves in touchdown areas. This is not excessive and does not require removal at present. For security reasons, photographs could not be taken, but several photographs previously taken by base personnel were obtained. Figure 29 shows the general condition of the pavement shortly after the grooving had been completed. This is representative of the present surface condition. Figure 30 shows a close view of an isolated area of very minor surface damage caused by the sawing operations.

d. Summary

After about 16 months in service, the runway grooving at Beale AFB is in excellent condition, and there is no indication that pavement deterioration due to the grooving will be a problem.

SECTION III

DISCUSSION

1. INSPECTION DATA

a. Field Inspections

The field inspections were made to determine whether the airfield pavement grooving which has been accomplished has contributed to pavement deterioration. The inspections covered grooving of PCC runway pavements at four airfields and AC runway pavements at two airfields. All of the grooving had been done within the past 2 years, and the long-time effect of the grooving on pavement deterioration cannot be predicted on this limited use. The inspection records provide an indication of the present pavement condition and also will be useful for future evaluation of the effects of the grooving on pavement deterioration.

b. PCC Pavement Condition

The sawed grooves in all PCC pavements were in excellent condition and there was no evidence of raveling or any other deterioration of groove edges. The grooved pavement surfaces also were in excellent condition at all airfields except at Kansas City where there were numerous small surface voids due to weathering out of unsound aggregate particles. Most of these surface defects apparently were present when the pavement was grooved. However, there also were many new surface voids and a few small spalls at joints and cracks which could be detected by their unweathered appearance. It is probable that the grooving did contribute to an increase in the number of new surface defects by exposing unsound aggregate particles which otherwise would have been protected by the surface mortar. Since the grooving at other airfields did not produce surface defects, it appears that the grooving contributes to surface deterioration only where there is an existing problem with surface defects due to unsound aggregate particles. Although no maintenance has been required at Kansas City Airport, the grooving could produce a more serious condition at any military airfield where a popout problem exists. Sawing of grooves very close to a joint edge or a crack could produce a thin sliver of concrete which would tend to ravel or break off. This condition would provide a slightly wider groove

but would not normally create a deterioration problem unless larger spalls occur due to exposure of unsound aggregate particles.

c. AC Pavement Condition

The inspections indicate that there was very little deterioration of groove edges in AC pavements. The very slight raveling or chipping at grooves observed in some areas at Washington National Airport has required no maintenance and has had no adverse effect on performance of the pavements. There was some evidence of minor surface deterioration at Kansas City Airport which appeared to be due to the grooving operations. This condition would not be a problem unless there would be progressive deterioration of the surface which is not indicated. Also there was some evidence of closing of grooves in touchdown areas which would reduce the effectiveness of the grooving from an operational standpoint. However, the groove closing was a kneading action, and is not a surface deterioration as there was no evidence of any raveling or breakup of the pavement surface. The distortion of the grooves in the touchdown areas of Washington National Airport is evidence of a shifting of the pavement surface course. While the grooving accentuates this shifting, it is not a causative factor. The movement appears to extend to a much greater depth than the 1/8-inch groove depth, and probably is related to the construction of the overlay. The grooving could be a factor only to the extent that it improves skid resistance which would increase shearing stresses in the pavement due to aircraft landing forces.

d. Rubber Deposits

There has been some accumulation of rubber in grooves in touchdown areas of all grooved runways inspected. The amount of rubber deposited probably is related to the traffic volume, type and size of aircraft, and groove configuration, but no information was obtained to evaluate these factors. Rubber deposits have not been considered a problem at any of the airfields inspected and no rubber removal has been required. In several instances it was indicated that the rubber in the grooves is relatively soft and tends to be removed by the jet blast of the aircraft. During the inspections, the rubber deposits could be readily scraped out with a knife blade.

e. Sawing Waste

A minor problem with dust from sawing waste was indicated at several airfields. This can be avoided by thorough flushing of the pavement immediately

after grooving until all cutting waste is completely removed. If any cutting waste is permitted to dry in the grooves, it is very difficult to remove and the flying operations will continue to blow up dust for a long period of time. Proper planning should assure that a large amount of water under high pressure is available for this flushing operation. Another condition which may result in incomplete removal of cutting waste is where the grooving operations are stopped for intermittent use of the pavement by aircraft. Where the runway must be kept in operation, adequate time should be provided for flushing the pavement after the grooving is stopped.

2. GENERAL COMMENTS ON GROOVING

a. Groove Details

Airfield grooving for operational use has been limited to runways, including both PCC and AC pavements. Various groove details and spacings have been used, and the only common feature has been that all airfield grooving has been transverse to the direction of traffic. A comparison of the groove details used for the various pavements is presented in the following tabulation.

Table I
COMPARISON OF GROOVE DETAILS

Airport	Pavement Type	Grooving Completed	Groove Dimensions, in. ⁽¹⁾		
			Width	Depth	Spacing
Washington Natl.	AC	April 1967	1/8	1/8	1
Kansas City Mun.	AC	May 1967	1/8	1/4	1
	PCC	May 1967	1/8	1/4	1
Kennedy Int.	PCC	Aug. 1967	3/8	1/8 ⁽²⁾	1-3/8
Beale AFB	PCC	Feb. 1968	1/4	1/4	1
Chicago Midway	PCC	Sept. 1968	1/4	1/4	1-1/4
Charleston, W. Va. Apt. ⁽³⁾	PCC	Nov. 1968	1/4	1/4	1-1/4
	AC	Nov. 1968	1/4	1/4	1-1/4
Seymour-Johnson AFB ⁽³⁾	PCC	Nov. 1968	1/4	1/4	2
	AC	Nov. 1968	1/4	1/4	2

(1) All airfield grooving transverse.

(2) Tapered groove with shaped rounded bottom.

(3) Grooving not inspected.

Where both PCC and AC pavements have been grooved at an airfield, the same groove pattern has been used. In general, the groove pattern used at each airfield has been considered satisfactory. However, at Kansas City Airport, it was indicated that a 1-inch clear distance between groove edges was considered preferable to the 1-inch center to center spacing used for this grooving. The tabulated data indicate that there has been a trend to the use of a 1/4-by-1/4-inch groove section at a spacing of 1-1/4 inches or greater. Grooves of wider spacings would be more economical to construct and should develop less pavement deterioration but these advantages must be balanced against groove details required for aircraft control. A program for evaluating 18 different groove patterns is now being conducted by NASA and FAA, but there are no criteria for optimum groove details at present.

b. Reduction in Pavement Thickness

The reduction in pavement thickness due to grooving is equal to the groove depth. Since most of the Air Force PCC pavements that might be grooved have a thickness of 12 inches or more, the maximum reduction in thickness would be about 2 percent for a 1/4-inch groove depth and 1 percent for a 1/8-inch groove depth, with lesser reductions for pavements with thicknesses greater than 12 inches. This reduction is within design and construction limitations and normally should have no deleterious effect on structural performance. However, where there is evidence that a pavement is being overloaded, consideration should be given to the possible effect of a reduction in the thickness of the pavement due to the grooving. Use of a 1/8-inch groove depth would be preferable in this case.

c. Surface Deterioration

The grooved airfield pavements inspected generally were in excellent condition, and only one airfield had surface defects. No "D" cracking was observed in any of the pavements. Grooving exposes more pavement surface area as well as new sawed aggregate surfaces which would tend to increase the possibility of surface deterioration. However, the general indication is that grooving does not cause surface deterioration where such defects are not present prior to the grooving. Where there is an existing problem with popouts or other surface defects, an increase in these defects can be expected.

d. Groove Deterioration

(1) PCC Pavements

All grooves in PCC pavements were sharply outlined and there was no evidence of chipping or raveling at edges of grooves due to traffic or weather. The beveled groove shape used at Kennedy International Airport has given satisfactory performance, but there is no indication that this shape is better than the square edge groove. Intersections of grooves with existing cracks at an acute angle could produce thin slivers of concrete which would tend to chip out. This would tend to produce a slightly wider groove in a small area, but there is no indication that this would cause deterioration of the grooved pavement. Overlapping of the grooving should be avoided as the resulting thin sections tend to break out during grooving and under the action of traffic.

(2) AC Pavements

A small amount of chipping or raveling of fine aggregate particles from groove edges can be expected in some AC pavement areas but this deterioration has been very minor. A more common condition is the tendency of grooves in some areas to close under traffic. While this closing of grooves would tend to reduce their effectiveness for aircraft operations, it appears to have little effect on pavement deterioration.

SECTION IV
CONCLUSIONS

The pavement inspections indicate that the grooving which has been accomplished during the past 2 years has not caused any appreciable deterioration of either PCC or AC pavements.

Because of the limited period that the grooving has been in use, only a general evaluation of the effects of grooving on pavement deterioration can be made. The following factors appear to be pertinent to the performance of grooved pavements:

- a. Grooving does not cause surface deterioration in PCC pavements which have no surface defects prior to grooving. Where there is an existing problem with popouts or other surface defects, an increase in these defects can be expected.
- b. Some closing of grooves due to traffic in touchdown and other heavy traffic areas in AC pavements can be expected. There is no indication that this closing of grooves will result in any deterioration of the pavement surface.
- c. Chipping or raveling at edges of grooves due to weather and traffic does not appear to be a problem in either PCC or AC pavements.
- d. Some rubber deposits tend to accumulate in the grooves, but no removal has been necessary from any of the grooved runways in operation. There is some indication that these rubber deposits are softer than surface deposits, and also some indication that the rubber deposits tend to be removed by the jet blast from aircraft. The rubber deposits are not pavement deterioration and are not considered to be a problem by operations people.

SECTION V
RECOMMENDATIONS

It is recommended that periodic inspections be made of grooved PCC and AC pavements to provide additional information on the long-time effect of grooving on pavement deterioration.

Kansas City Municipal Airport

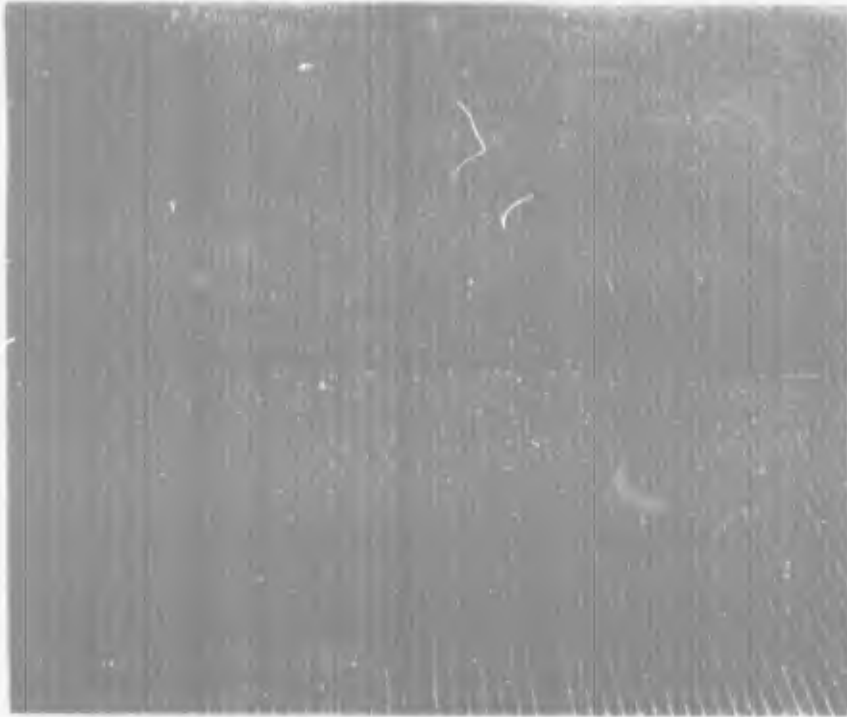


Fig. 1. Grooved AC overlay pavement near intersection with Taxiway D.

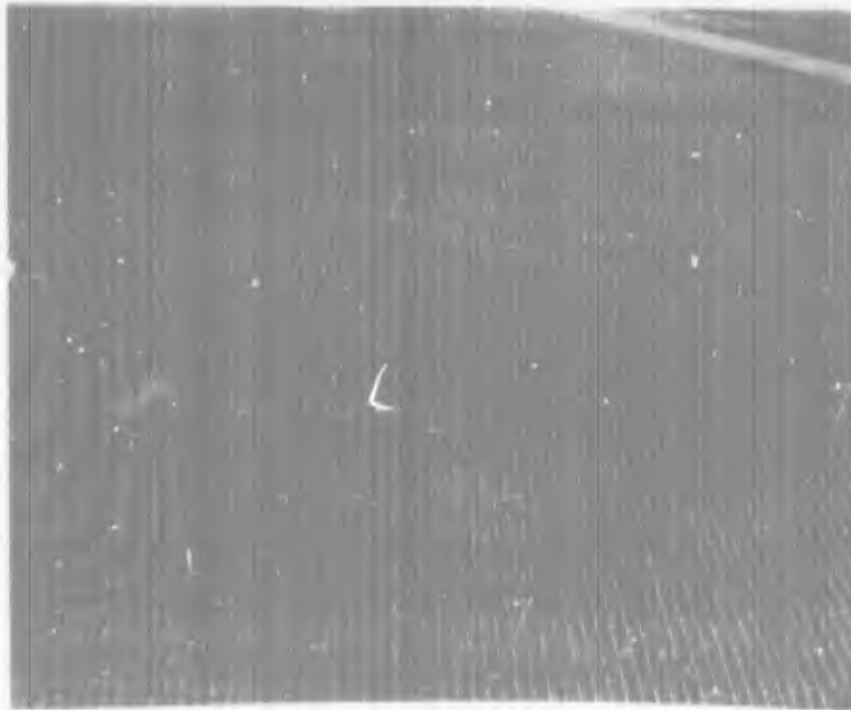


Fig. 2. Grooved AC pavement near Taxiway D showing minor surface deterioration

Kansas City Municipal Airport

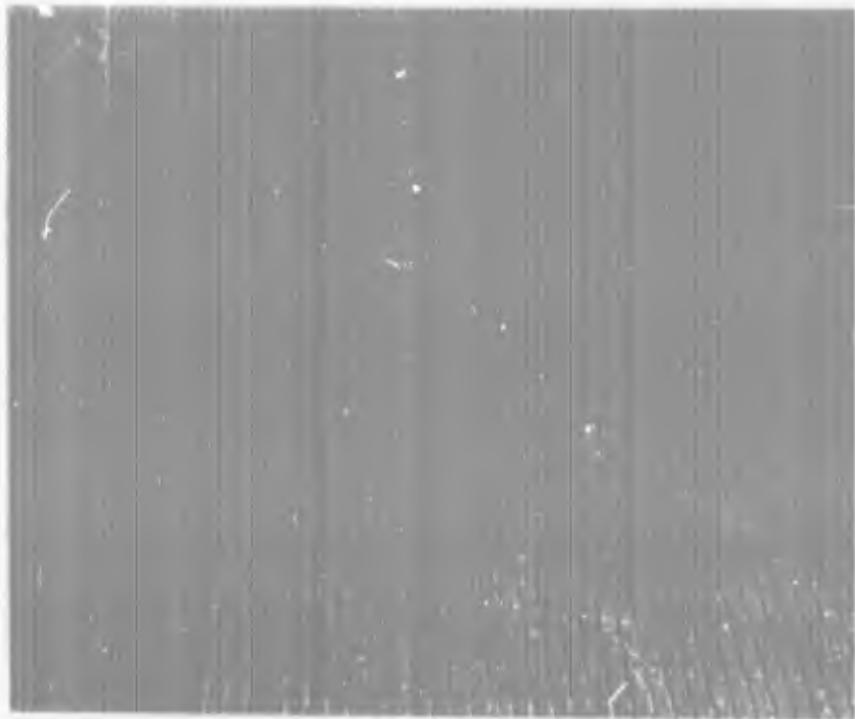


Fig. 3. AC Grooving near 36 end of overlay showing good condition of grooves

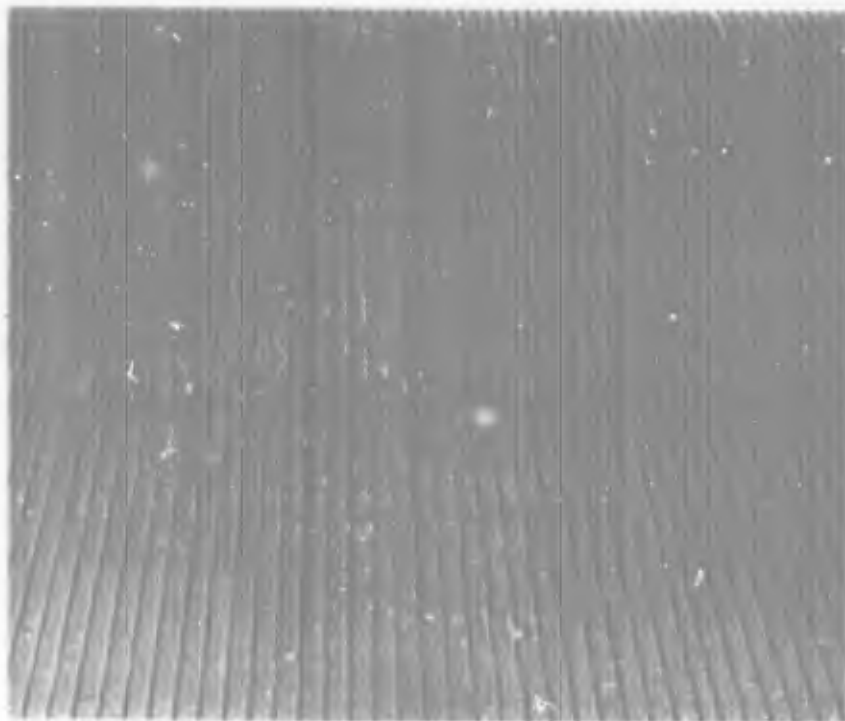


Fig. 4. Minor deterioration of AC grooving due to sawing

Kansas City Municipal Airport

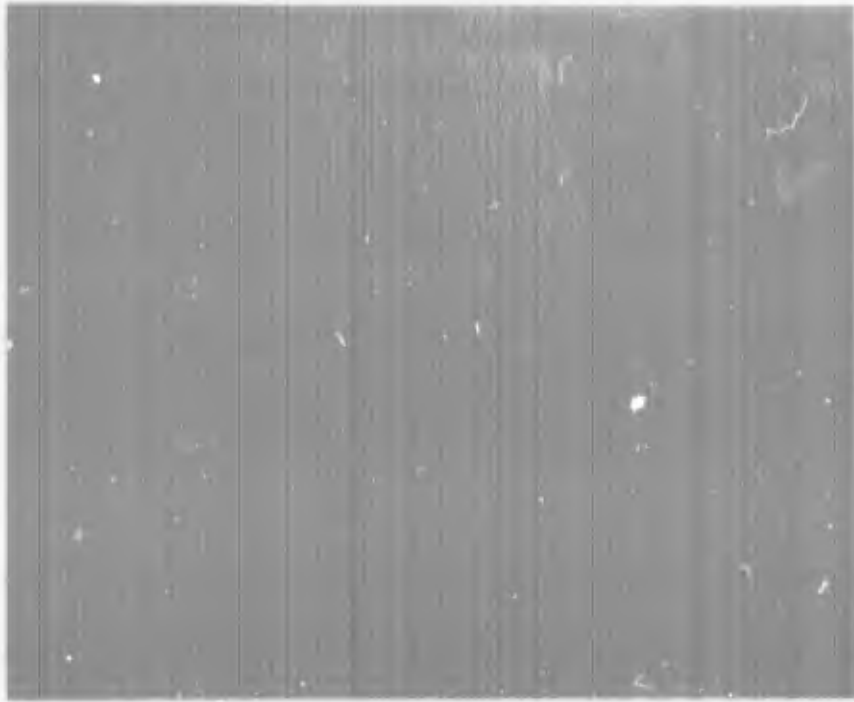


Fig. 5. Grooved AC pavement showing groove closing in foreground

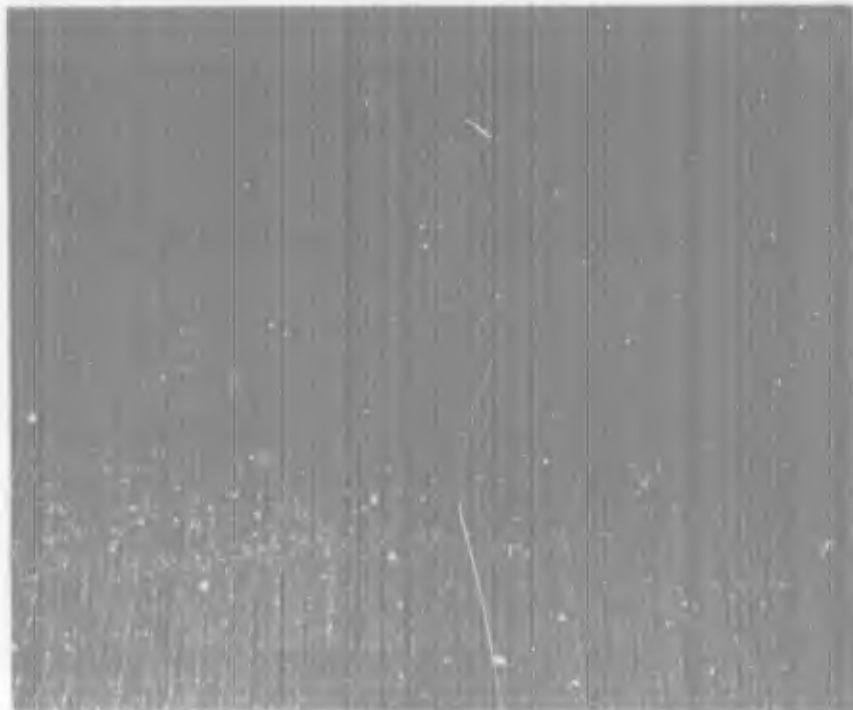


Fig. 6. Close view of groove closing

Kansas City Municipal Airport

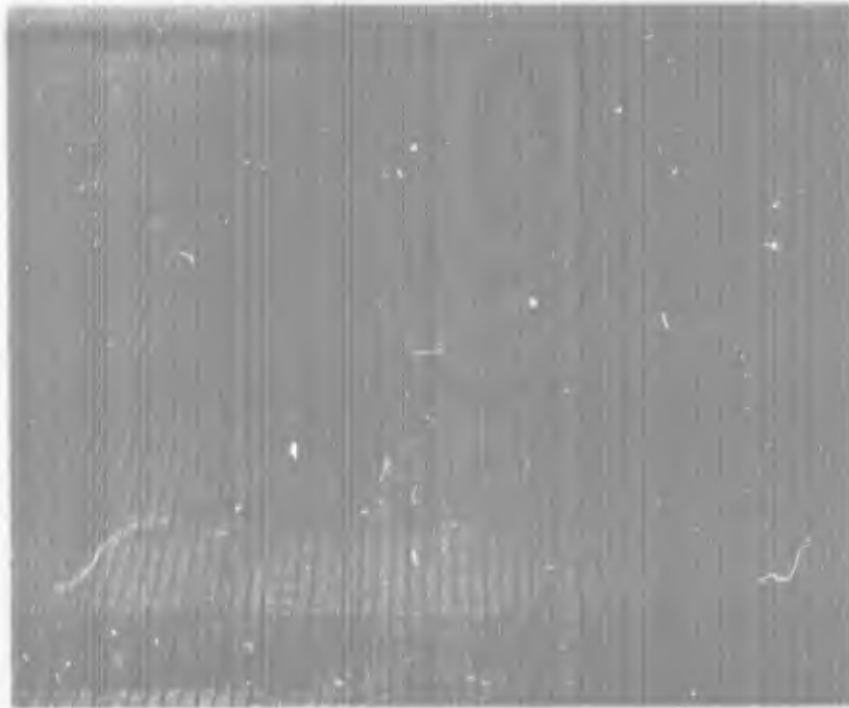


Fig. 7. PCC grooving near 36 end, outer lanes. Small holes in surface are weatherouts.

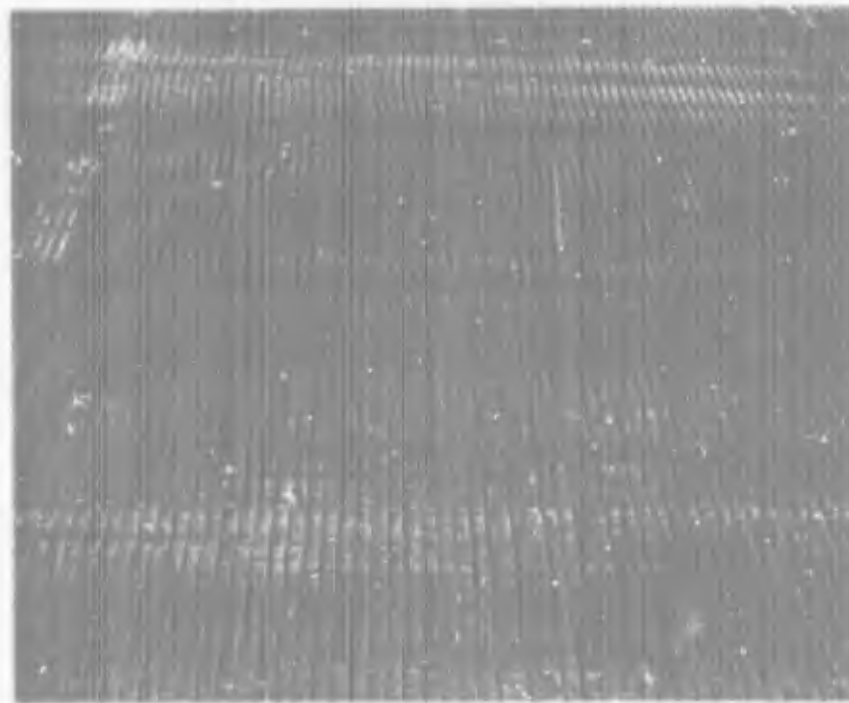


Fig. 8. Same area as Fig. 7, central lanes. Pavement darkening due to surface deposits.

Kansas City Municipal Airport

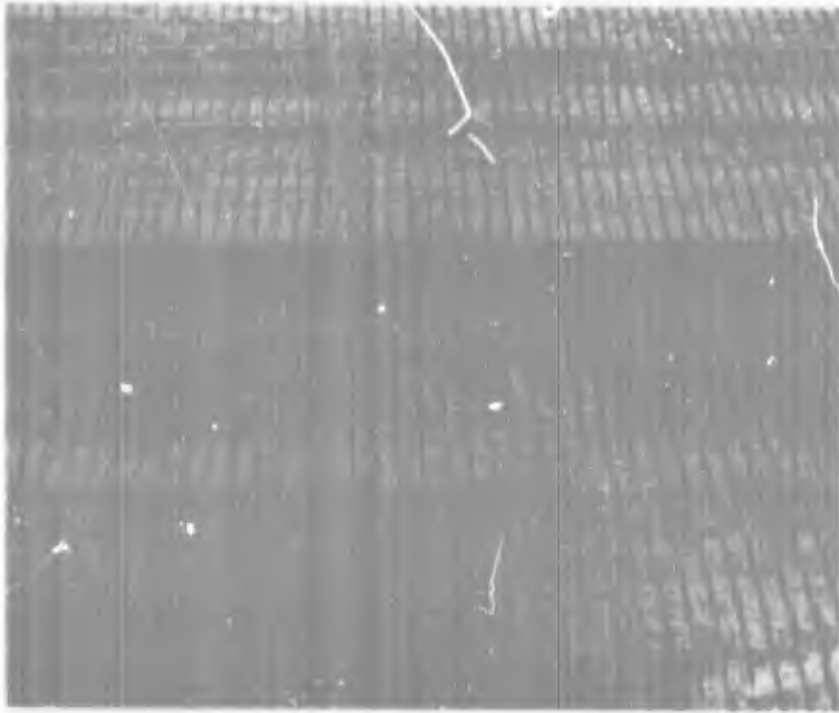


Fig. 9. Close view in traffic lanes in PCC pavement near 36 end of runway

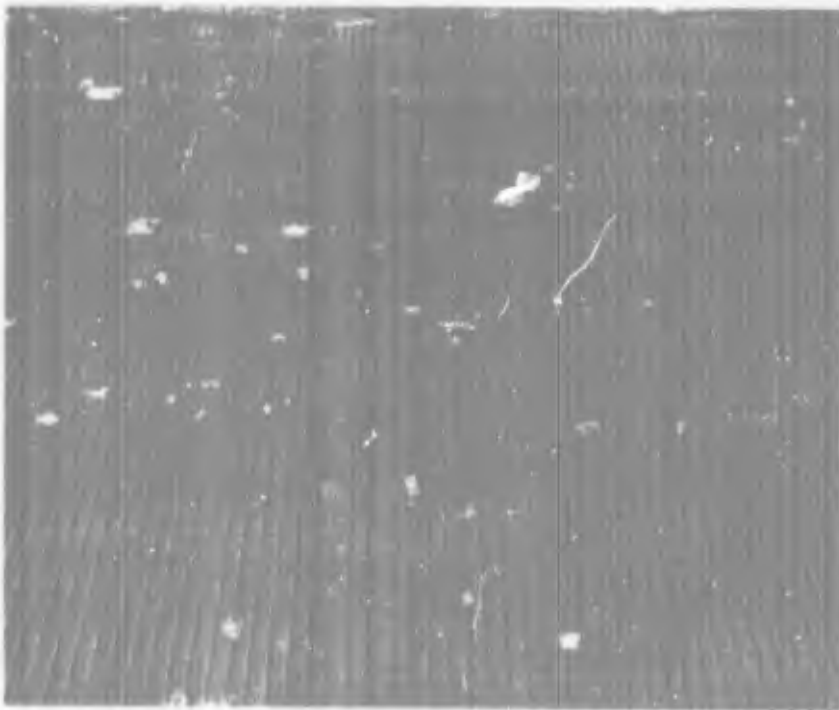


Fig. 10. PCC grooving on 36 end near juncture with AC overlay.

Kansas City Municipal Airport

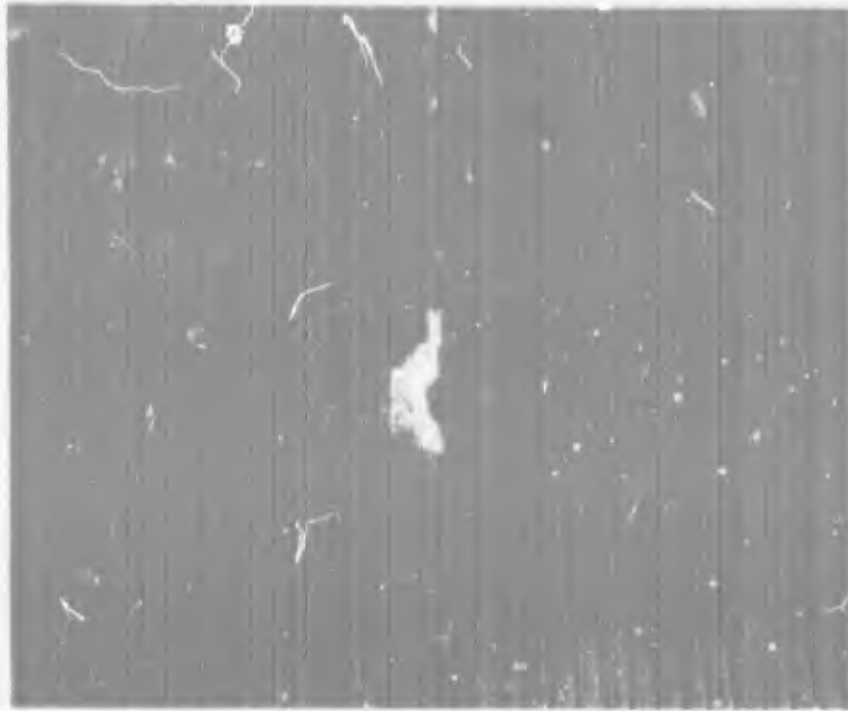


Fig. 11. Close view of recent spall



Fig. 12. Close view showing grooving overlap

Chicago Midway Airport

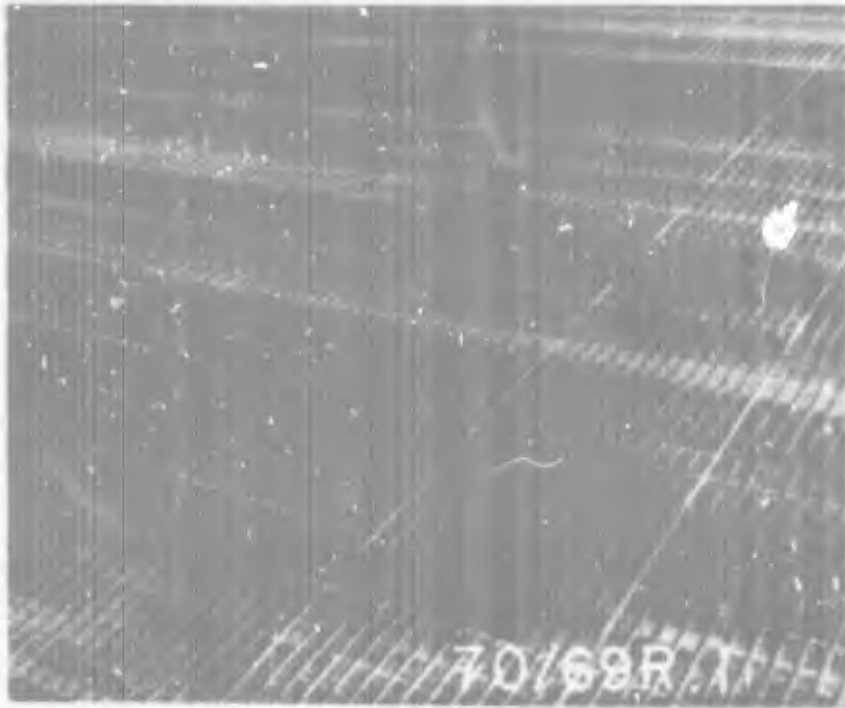


Fig. 13. Grooved pavement, center lanes
in touchdown area S.E. end of Runway
13R/31L



Fig. 14. Same area as Fig. 13, with
outside lane in foreground showing less
discoloration

Chicago Midway Airport

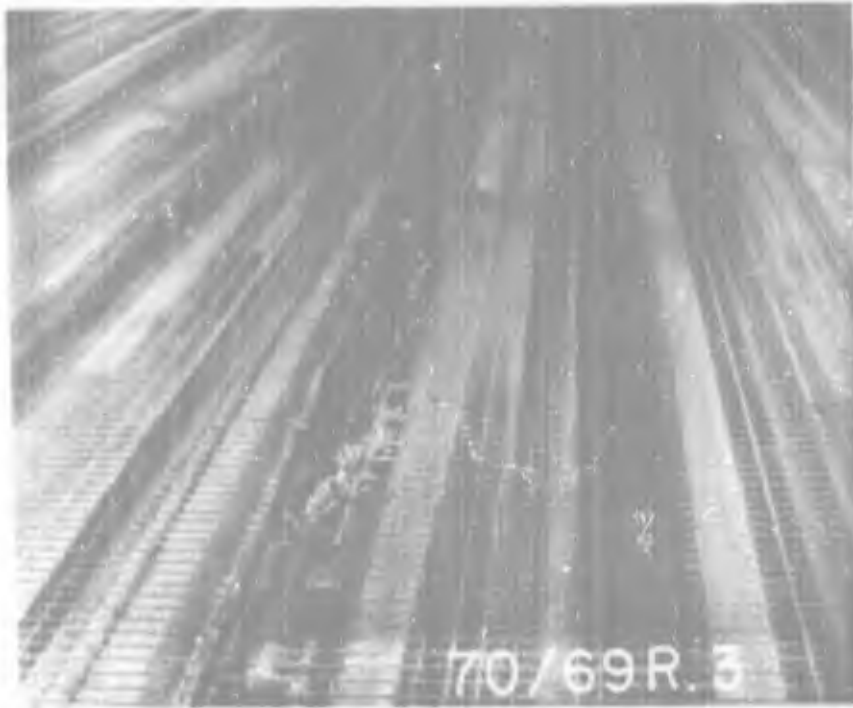


Fig. 15. Spalling along center longitudinal joint of runway



Fig. 16. Joint spall repair with AC concrete

Chicago Midway Airport



Fig. 17. Grooving at transverse crack in continuously reinforced pavement.

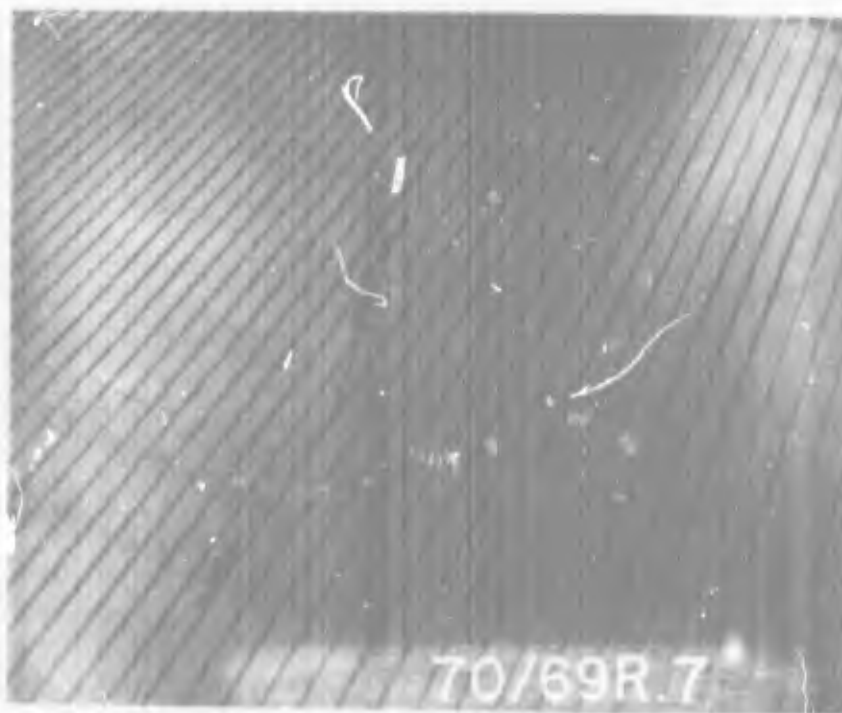


Fig. 18. Close view in same area as Fig. 17

J.F. Kennedy International Airport

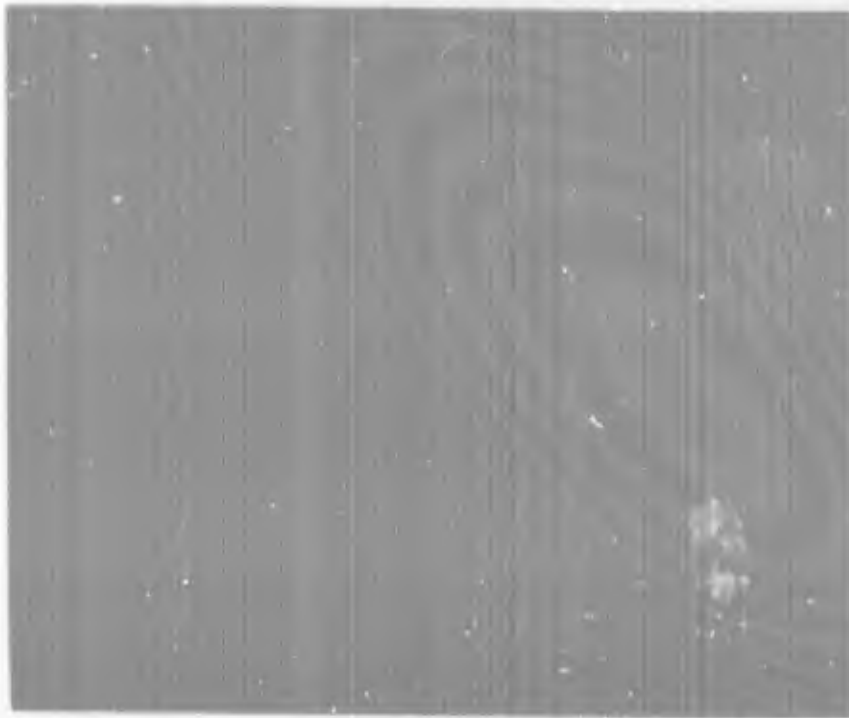


Fig. 19. Typical grooving in Runway 4R/
22L showing excellent condition of grooves



Fig. 20. Close view of grooving in same
general area as Fig. 19

J.F. Kennedy International Airport

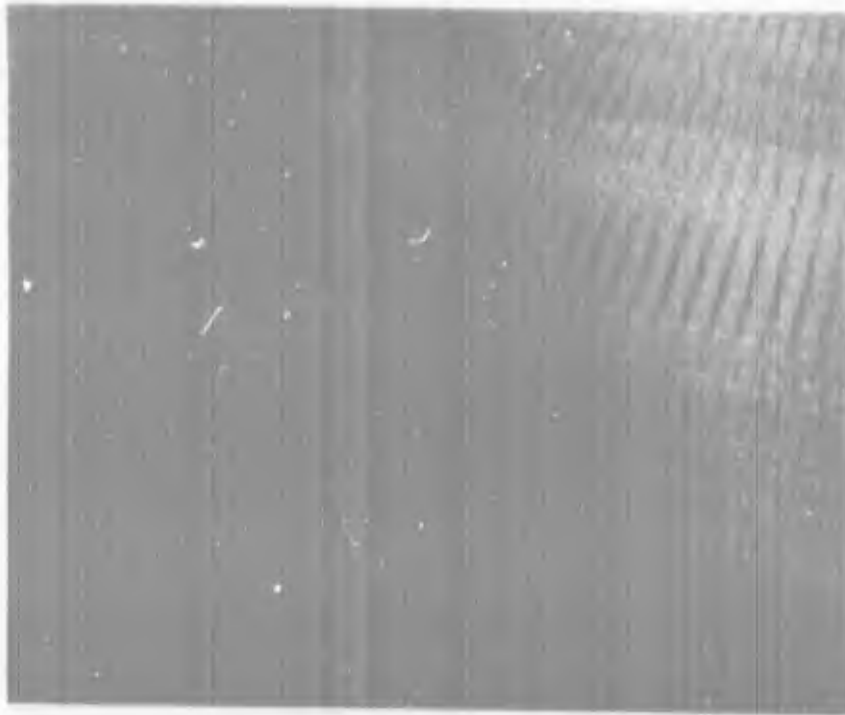


Fig. 21. Deficiency in grooving due to low area in pavement surface

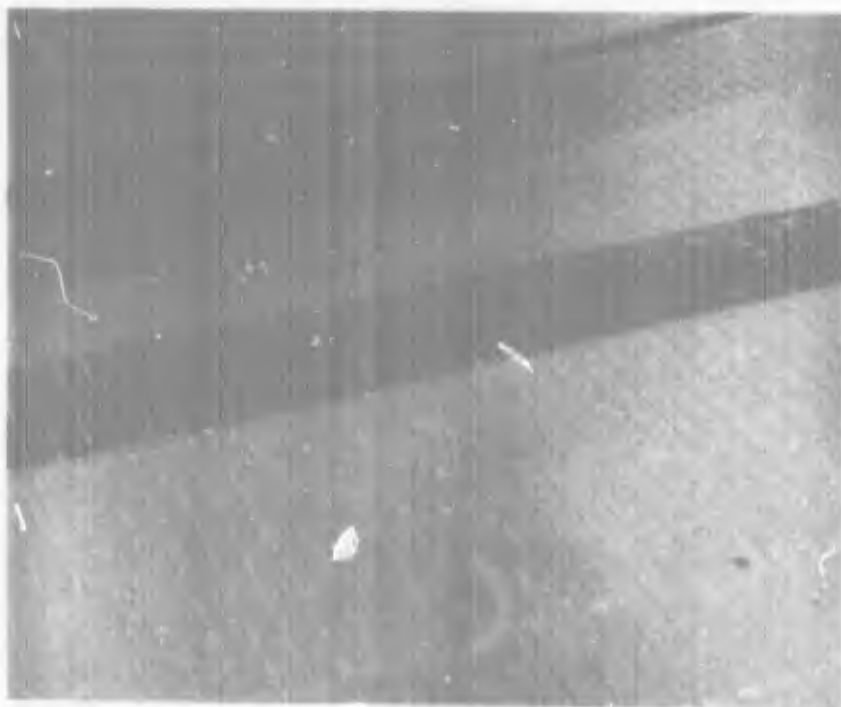


Fig. 22. FAA environmental test section with grooves 1/8-in. x 1/8-in. at 1½-in. spacing

Washington National Airport

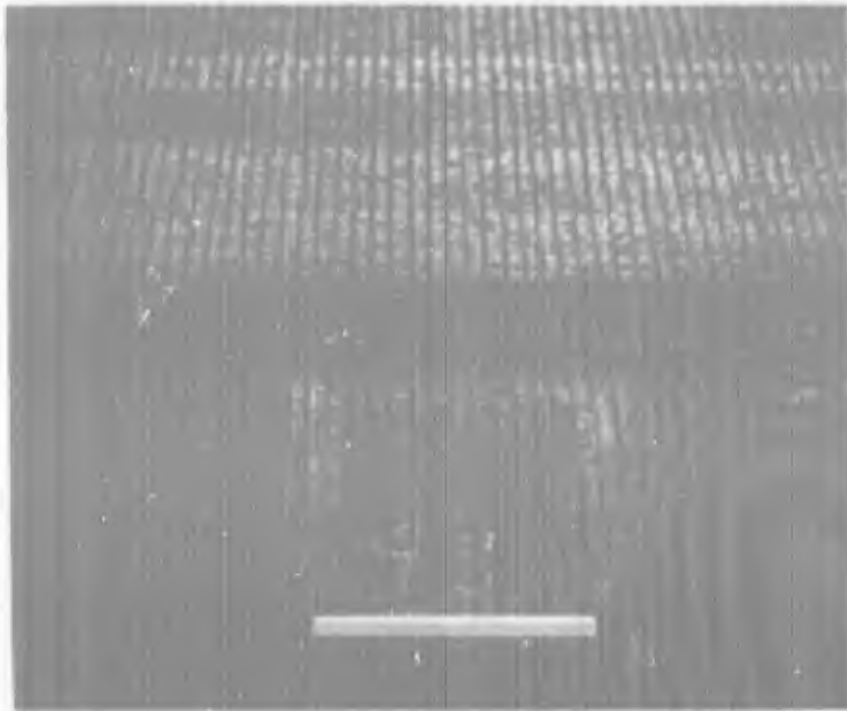


Fig. 23. General View showing excellent condition of grooving near south end of runway

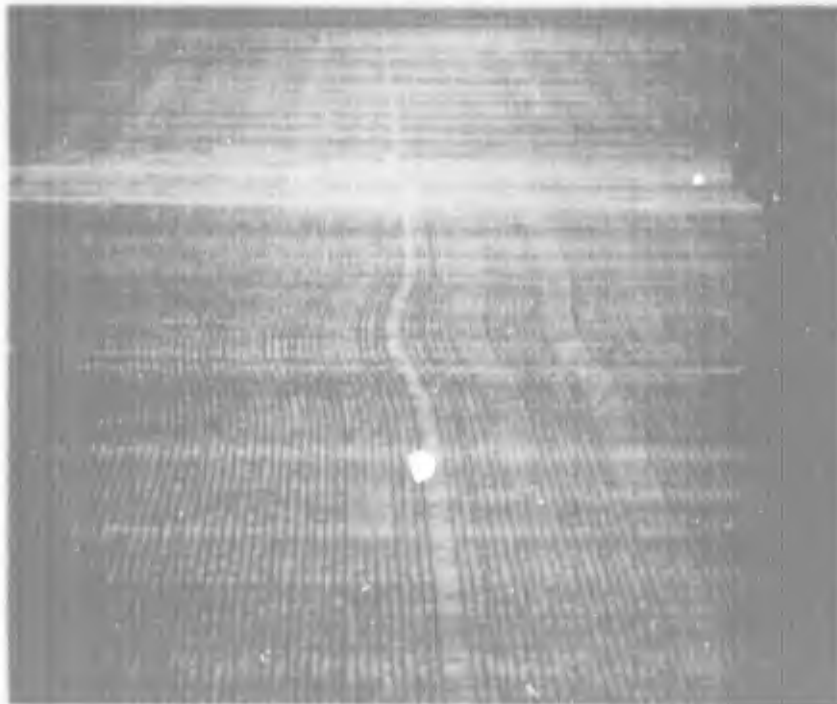


Fig. 24. Shifting of pavement surface in touchdown area near south end of runway

Washington National Airport

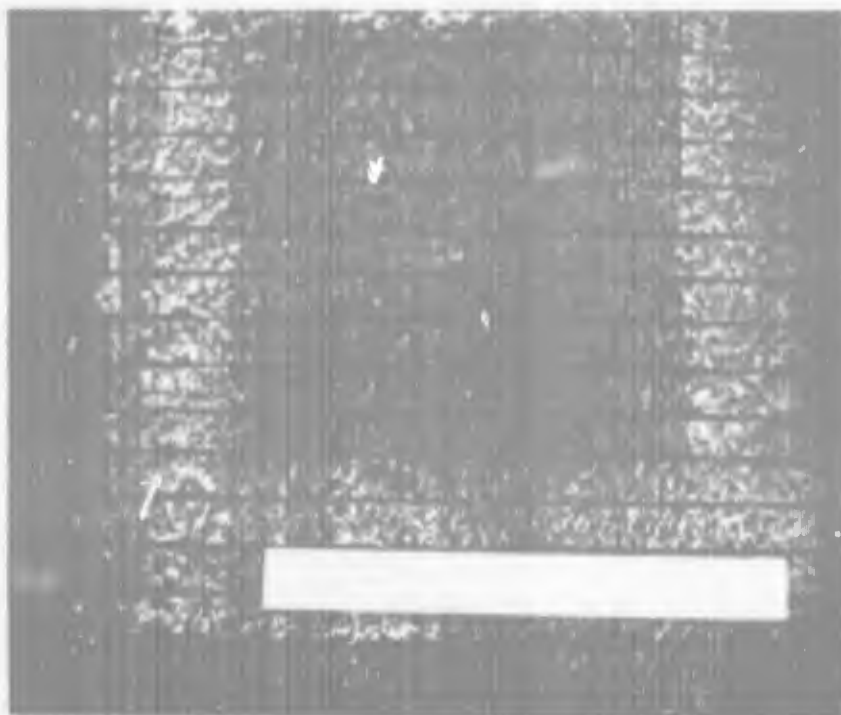


Fig. 25. Close view of rough textured AC pavement surface

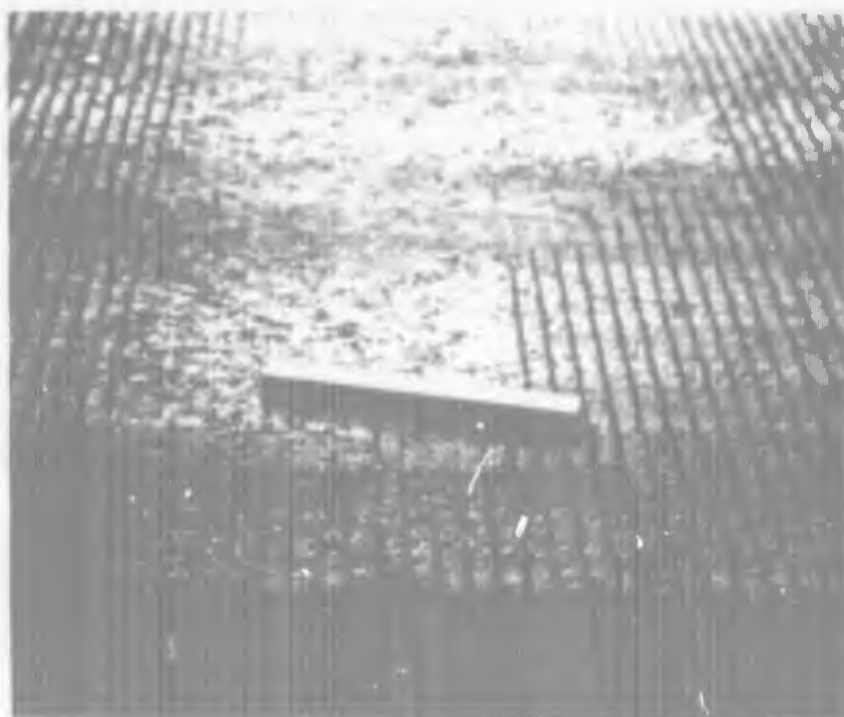


Fig. 26. Skipped area due to surface depression

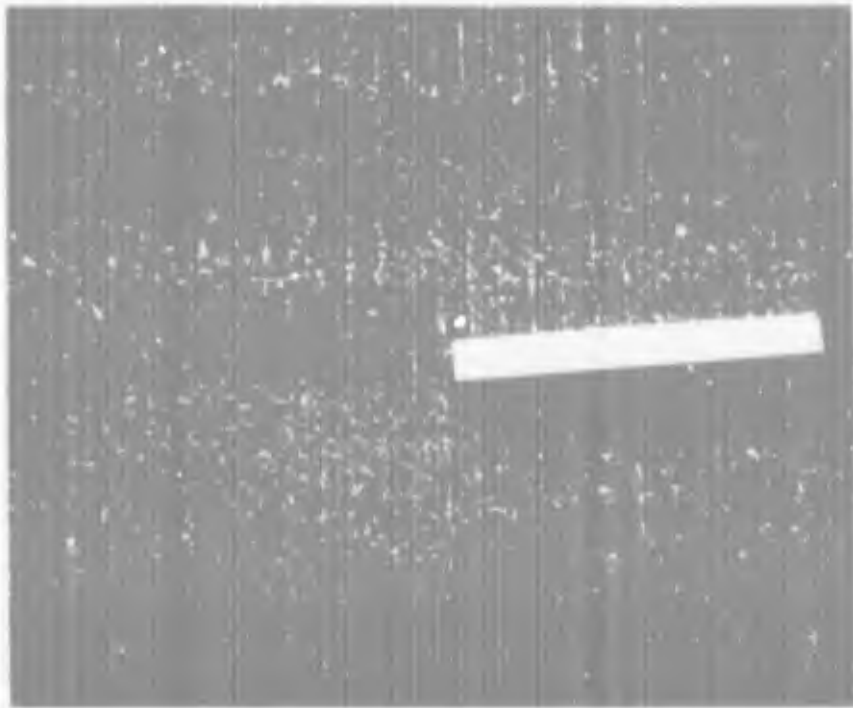


Fig. 27. Close view of rubber deposit in grooved pavement

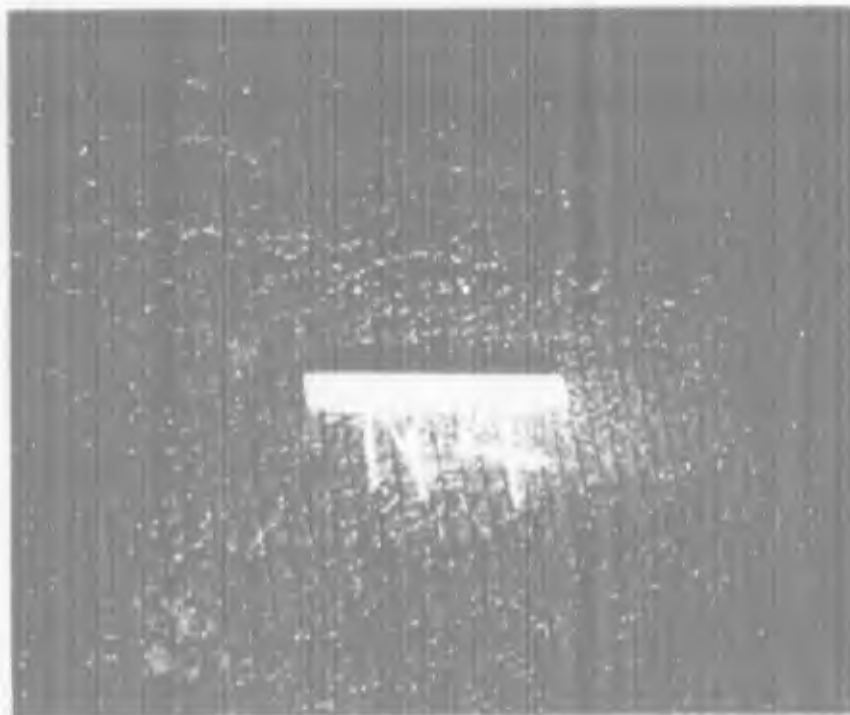


Fig. 28. Minor deterioration at intersection of grooving with crack in pavement

Beale Air Force Base



Fig. 29. General view of grooved runway pavement showing excellent condition of grooving

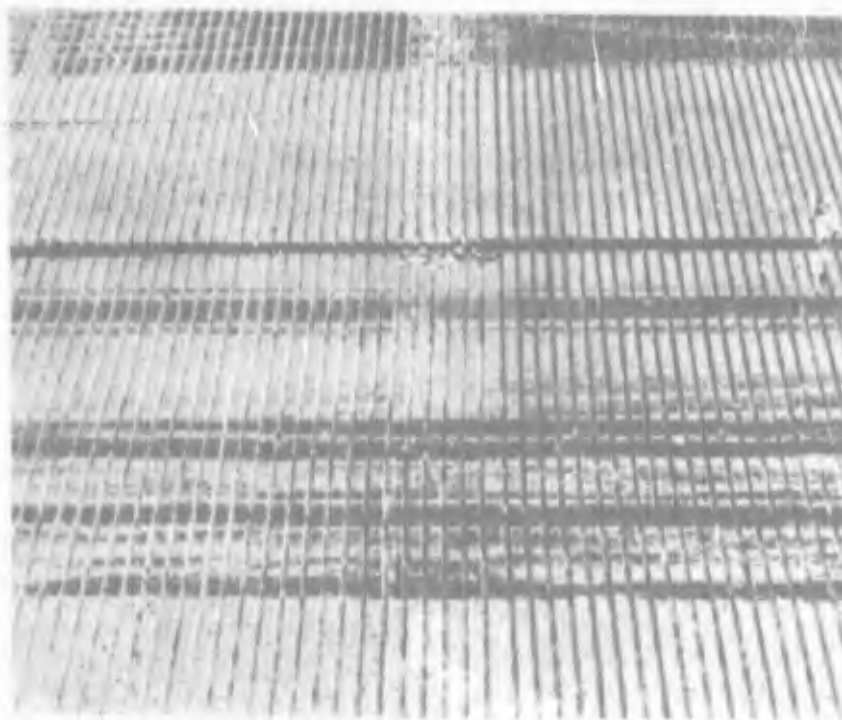


Fig. 30. Minor spalling at joint which occurred during grooving

REFERENCES

1. National Aeronautics and Space Administration, Pavement Grooving and Traction Studies, Report No. NASA SP-5073, Report on conference held at Langley Research Center, Hampton, Virginia, 18-18 November 1968.
2. Federal Aviation Administration, Environmental Effects on Airport Pavement Groove Patterns, Report No. FAA-RD-69-37.
3. Narrow, I., Study of Effects of Grooving on Pavement Deterioration--Survey of Grooving Operations, Department of the Army, Ohio River Division Laboratories, Corps of Engineers, February 1969.

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13. ABSTRACT (Distribution Limitation Statement No. 2) A study was made on the deterioration effects of deliberate grooving on airfield pavements. Grooving is done to reduce hydroplaning and skidding. Grooved pavements were inspected at four civilian and one military airfield. The inspection included portland cement concrete (PCC) runways at four airfields and asphaltic concrete (AC) runways at two airfields, all of which had been grooved within 2 years before the inspection. Grooves in all PCC runways were in excellent condition with no evidence of deterioration except in one case where numerous small popouts and weatherouts have occurred. Grooving had apparently contributed to an increase in these defects. The AC runways showed minor groove deterioration in some areas, and some obliteration of the grooves in one touchdown area. Rubber deposits in grooves have occurred in both PCC and AC pavements, but no removal of the rubber has been required. Grooving has not at present resulted in any significant deterioration of either PCC or AC runway pavements. Some closing of grooves in touchdown areas of AC surfaces can be expected, but this is not considered to be actual pavement deterioration. Where PCC pavements have previous popouts or other surface defects, grooving can be expected to increase these defects. PCC and AC runway pavements should continue to be inspected periodically to determine the long-time effects of grooving.		

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Grooving Skid resistant Hydroplaning Airfield pavement Pavement deterioration						