18. PAVEMENT GROOVING AT JOHN F. KENNEDY INTERNATIONAL AIRPORT

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SUMMARY

In August of 1967, The Port of New York Authority completed the grooving of essentially the entire surface of runway 4R-22L at John F. Kennedy International Airport. The grooving pattern was somewhat different from that used at other airports. Major problems included the requirement to return the runway to service on short notice and the disposal of the concrete dust generated by the grooving operation. After 16 months of use, all observations indicate that the grooves are performing their intended function by reducing aircraft stopping distance during wet and flooded conditions. No pavement deterioration or maintenance problems have been noted to date.

INTRODUCTION

The Port of New York Authority had for many years followed closely the efforts of various agencies to develop an improved or modified pavement surface that would increase the coefficient of friction between aircraft tires and the pavement surface during wet or flooded conditions, thereby minimizing the tendency of aircraft to hydroplane under these conditions. Most of the original work with grooved and porous pavement surfaces was done by the British and dates back to 1956. In this country, the California Department of Highways first applied the principle of surface grooving to roadways in locations where accident rates were high under wet or flooded conditions. A great deal of analytical work on the phenomenon of aircraft hydroplaning was done by the National Aeronautics and Space Administration (NASA), and in 1966 a concentrated effort in the area of runway grooving was initiated by NASA.

On the basis of the generally favorable results reported by the British, the California Highway Department, and NASA, The Port of New York Authority, late in 1966, decided to install grooves on a fully operational runway. The grooving was supported by the using airlines through the Air Transport Association (ATA) and was intended to supplement the work being done by NASA at Langley Field and Wallops Island, as well as the environmental testing being carried out through joint NASA-FAA auspices at various locations throughout the country.

INSTALLATION

Runway 4R-22L at Kennedy International Airport (fig. 1) was the logical choice for a grooving test for several reasons. The runway is fully instrumented from both the northeast and the southwest and accepts virtually all the bad-weather landings at the airport. The runway, which is 8400 feet in length, received approximately 70 000 landings during 1967. This level of activity, which indicates the advisability of grooving this particular runway, is also indicative of the operational problems which would attend any prolonged shutdown of the runway.

With the runway selected, decisions then had to be made on how much of the runway to groove, the type of groove to be used, and the pattern to be specified.

While it was recognized that grooving might be limited to the area in which hydroplaning was most likely to occur, the exclusion of any one portion of the runway was difficult to justify. The fact that the runway was used extensively in both directions extended the area of potential hydroplaning, leaving only relatively small areas at each end of the runway free of this problem. It was therefore decided to groove the entire runway, omitting only the concrete slabs that contained the Elfaka light units (see fig. 2) which, at that time, were the principal components of both the centerline and touchdown in-pavement lighting systems. (The centerline Elfakas have since been replaced by newer pancake-type fixtures.) Also omitted was the outer 5 feet of the runway pavement on each side to facilitate the turnaround of the cutting equipment without damage to shoulder pavement or runway edge lights.

Preliminary work done by NASA at that time, as well as reports from The United Kingdom, seemed to indicate that a pattern which provided approximately 1 inch of ungrooved pavement between adjacent grooves would, while helping under wet and slippery conditions, not reduce the coefficient of friction under dry conditions. It was therefore decided to establish a transverse pattern which would provide this 1-inch "land" between the grooves.

In selecting a groove depth and shape, the lack of any long experience in this area dictated a most conservative approach. Because of the ever increasing weight of aircraft and resulting pavement loading, any reduction in the effective thickness of the concrete slab had to be held to a minimum. It was therefore decided that the depth of groove should not exceed 1/8 inch. It was also decided that, if at all practical, the sharp interior corners of a rectangular cut would be avoided because of the tendency of these corners to develop stress concentrations which could lead to the failure of the rigid slab. To further enhance the ability of the groove to resist deterioration, the use of a V-shaped groove was considered, and accelerated weathering tests were conducted on both rectangular and V-shaped grooves. It was anticipated that a V-groove might prove superior to a rectangular groove in withstanding spalling caused by the freezing of entrapped water, since its shape would permit the expanding ice to move up and out of the groove rather than bear against the sides. The tests, while not extensive, did confirm the superiority of the V-groove in this respect. It was also believed that the V-groove would offer greater resistance to spalling or raveling during construction, as well as in an operating environment, by virtue of its lack of right-angled edges. The V- or sinusoidal-shaped groove illustrated in figure 3 was therefore chosen.

In the preparation of plans and specifications for the work, the operational problem noted earlier had to be carefully considered by the Port Authority staff. More than 32 percent of all landings at the airport are performed on either runway 4R or 22L. During certain summer months when strong winds from the south and southwest prevail, this percentage can rise to as high as 58, in spite of a noise-abatement preferential-runway system that strongly discourages landing on runway 22L unless required by wind and/or visibility conditions. Because of this high volume of activity which could not be "switched off" the runway, an extended shutdown of the runway could not be considered. Based upon a knowledge of the production capability of equipment which could be used to accomplish the grooving, it was decided that the contractor would be permitted to work on the runway only during nonpeak hours, which, at that time, were 6:00 a.m. to 3:00 p.m., and would be required to clear the runway within one-half hour upon notice from the control tower whenever weather conditions necessitated the use of the runway. Since the contractor was guaranteed compensation for men and equipment idled during these interruptions, records were maintained which indicate that he was denied the use of the runway about 10 percent of the time.

The contract for the work was awarded in early 1967 to Master Waterproofers, the lowest of three bidders, in the amount of $157 490, or about $0.13 per square foot. The contractor started work on May 1, 1967, and used two groove cutters manufactured by Concut, Inc., of El Monte, California. These machines, one of which is shown in figure 4, were self-propelled and employed a 38-inch-wide rotating drum with diamond-impregnated cutting elements to establish the groove pattern. The production of each machine was somewhat less than the 20 000 square feet per day that can be anticipated on highway work because of the numerous turnarounds required in a transverse grooving operation, as contrasted with the longitudinal highway operation, as well as the requirement to vacate the work area whenever required by the aeronautical operation.

The disposal of the 300 000 pounds of concrete dust generated by the grooving operation was a potential problem. Because of the extreme susceptibility of turbojet engines to damage or failure due to the ingestion of foreign material, it was decided to assure that the runway surface was clear of concrete dust by continually flushing the residue to the drainage inlets in the paved shoulder along each edge of the runway. To provide the large volume of water that was required for this flushing operation, the contractor was permitted to connect to the fire hydrant system that parallels the runway. Additional hand work was required along the shoulder to remove accumulated sediment around the inlets and in the silt traps.

Another problem to be considered in the grooving of runways that accommodate a high volume of landings is the handling of paint buildup. With the number of operations on both runways 4R and 22L, the accumulation of rubber deposits can require the repainting of the threshold portion of each runway as often as four times a year. In some areas, the buildup of sandwiched layers of paint and rubber deposits exceeded the 1/8-inch groove depth. In these areas, large sections of the surface tended to peel off after the grooving operation, leaving ungrooved spots. This condition is depicted in figure 5. The best remedy for this problem was found to be the grinding off of these buildups prior to the grooving operation with a "Bump Cutter" manufactured by Concut.

No other significant problems were encountered, and the contract work was completed on schedule by August 1, 1967.

EVALUATION

Since completion of the work, over 100 000 landings have been made on the runway (large aircraft do not take off from this runway because of length limitations). Regular inspections of the pavement reveal no surface damage or signs of pavement distress. In addition, no complaints of increased vibration or aircraft tire wear have been received from the users of the runway.

While admittedly only one relatively mild winter, from a snow-removal point of view, has been experienced since the grooving, no damage to the pavement caused by snow plowing has been observed. Normal snow-removal procedures were followed without special precautions for the grooved surface. Little or no ice removal was required last winter, and no observation can yet be made on the possibility that the grooves may actually facilitate ice removal because of the serrations built into the ice pattern. The effect of snow and ice removal operations upon the grooved pavement, as well as the effect of the grooves upon snow and ice removal operations, will be closely watched during future winters and any significant findings will be reported.

One problem which was anticipated but which has not materialized to date was the reaccumulation of rubber deposits within the grooves themselves. Apparently, the rubber material deposited in the grooves is not of the vulcanized type which is normally deposited on the flat surfaces, and so far this relatively soft material has generally been cleaned by the jet blast of the aircraft. In the future, should the grooves become filled to the point where drainage is affected, the surface could be treated with a cresylic acid compound which has been used successfully in the past to remove rubber.

Prior to the installation of the grooves, the coefficient of friction under dry and wet conditions was measured along the center and edges of the runway by means of a modified Swedish Skiddometer or braking trailer operated at speeds from 10 mph to 60 mph. In December 1967, after the grooving had been completed, these tests were repeated with the same equipment. The results indicated a substantial increase in the coefficient of friction under wet conditions. The magnitude of the improvement appeared to increase with the speed of the test vehicle, which, as noted earlier, attained a maximum speed of 60 mph. Thus the grooves are apparently effective at the higher aircraft speeds at which hydroplaning is likely to occur.

Questionnaires soliciting the comments of pilots on the effectiveness of the grooving were circulated by the ATA, and the results are reported in reference 1. Pilot comments that have come to the attention of the Port Authority have, without exception, been quite favorable. The two most common pilot reactions involved the elimination or reduction of the water spray normally encountered in landing during a heavy rain and the ability to exit the runway comfortably with a shorter ground roll under wet conditions. Visual observations of landings on runway 4R during wet runway conditions have confirmed that a higher percentage of the B-707 and DC-8 aircraft are now able to use the high-speed taxiway exit located approximately 2000 feet closer to the landing threshold. Likewise, in landing on runway 22L, a higher percentage of these same aircraft now seem to be using the taxiway exit about 2000 feet closer to the landing threshold. In addition to this apparent increase in the factor of safety in wet-runway landings, the use of a closer turnoff reduces the runway occupancy time for these operations and permits possible increases in the acceptance rate for the runway. The ability to use these turnoffs in all weather conditions also reduces the taxi distance to the individual terminals in the central terminal area at Kennedy.

THE FUTURE

Because of the apparent operational advantages offered by grooved runways as well as the lack of any demonstrated or anticipated maintenance problem, the Port Authority is seriously considering the grooving of other runways at our airports. We also plan, during next year's construction season, to groove the high-speed taxiway turnoffs on runway 4R-22L at Kennedy. These taxiways will represent our first significant grooving experience with asphalt pavement and will, it is hoped, provide the background required to confidently groove the 80 acres of asphalt runway pavement at Newark and the 35 acres at LaGuardia.

The grooving of runways at LaGuardia, while strongly indicated from an operational viewpoint, will require the solution of some unique problems. Both runways at LaGuardia were recently extended to a length of 7000 feet with extremely costly pier structures, and further expansion is not considered feasible. Any improvement which would, in effect, increase the runway length available during wet and flooded conditions would, of course, have considerable merit. One of the problems at LaGuardia which must be considered, however, is the structural effect of the grooves upon the prestressed-concrete deck, the design of which is currently being reviewed to determine its ability to accommodate various versions of the "Airbus." Another problem is the development of a groove especially tailored to the unusual settlement conditions at LaGuardia. The intersection of the runways lies immediately adjacent to the structural extension of the runways, and the differential settlement rate between the land and pier requires the overlay of the intersection with as much as 4 inches of asphalt each year.

CONCLUSION

After 1 year, The Port of New York Authority is pleased with the performance of the grooves installed on runway 4R-22L at Kennedy, plans the grooving of additional taxiways at Kennedy within the next year, and hopes eventually to groove all other runways where operational advantages can be gained without compromise of pavement integrity or maintainability.

REFERENCE

1. Abbott, Edwin W.: Commercial Airlines and the Grooved Runway Concept. Pavement Grooving and Traction Studies, NASA SP-5073, 1969. (Paper No. 9 herein.)

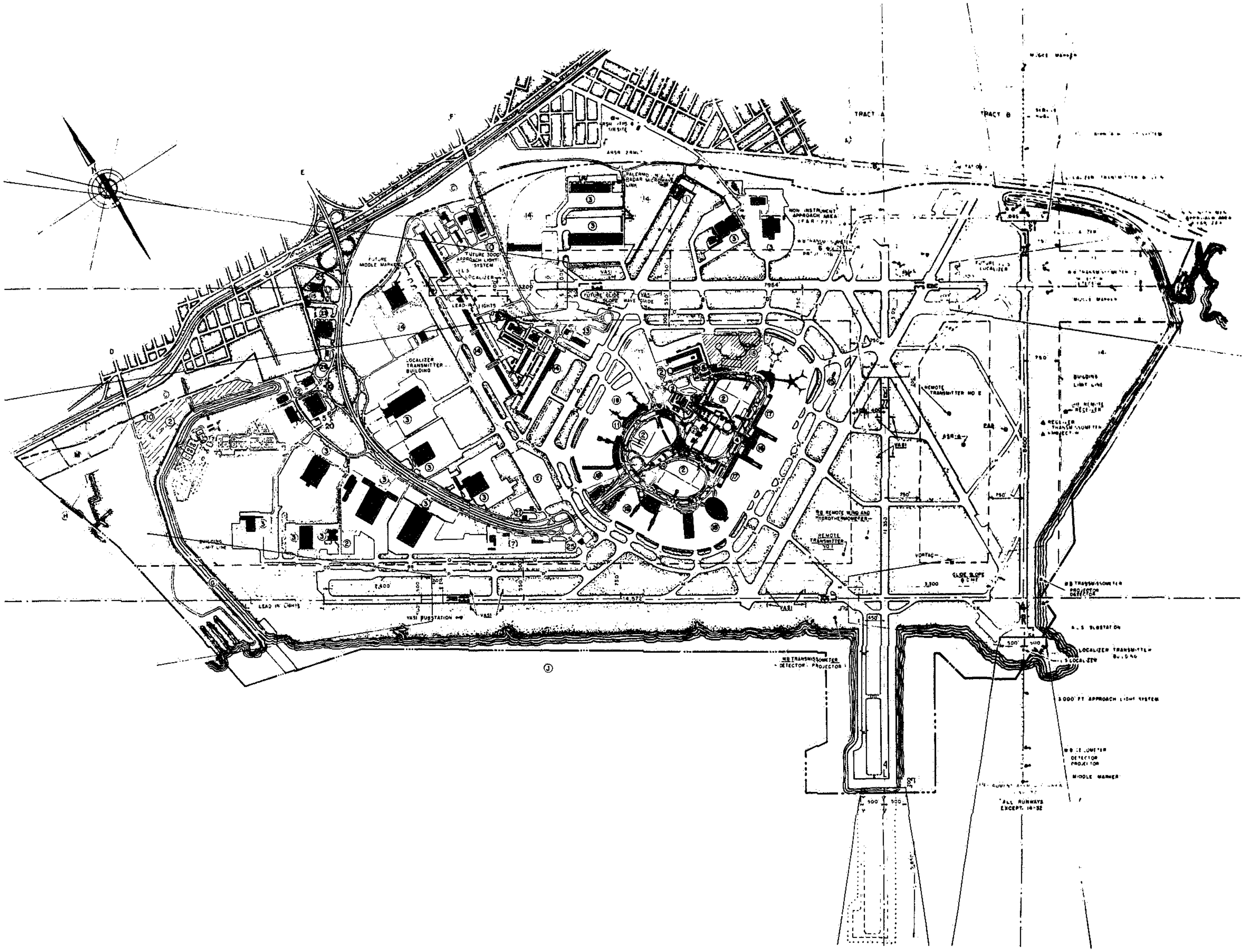

Figure 1.- Master plan of John F. Kennedy International Airport.

Figure 2.- Grooved runway with ungrooved slabs containing Elfaka light units.

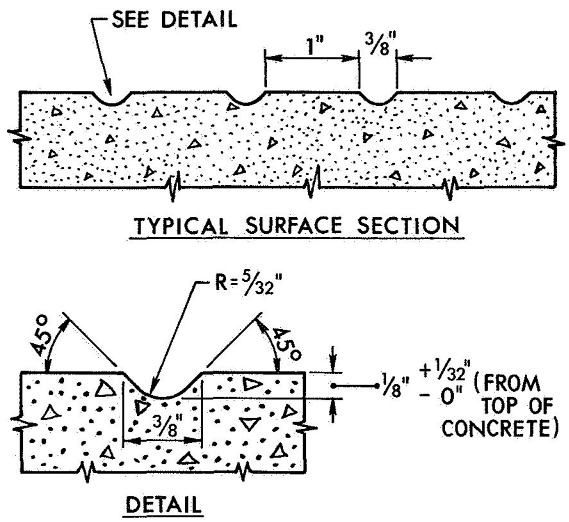

Figure 3.- Cross section of runway grooves.

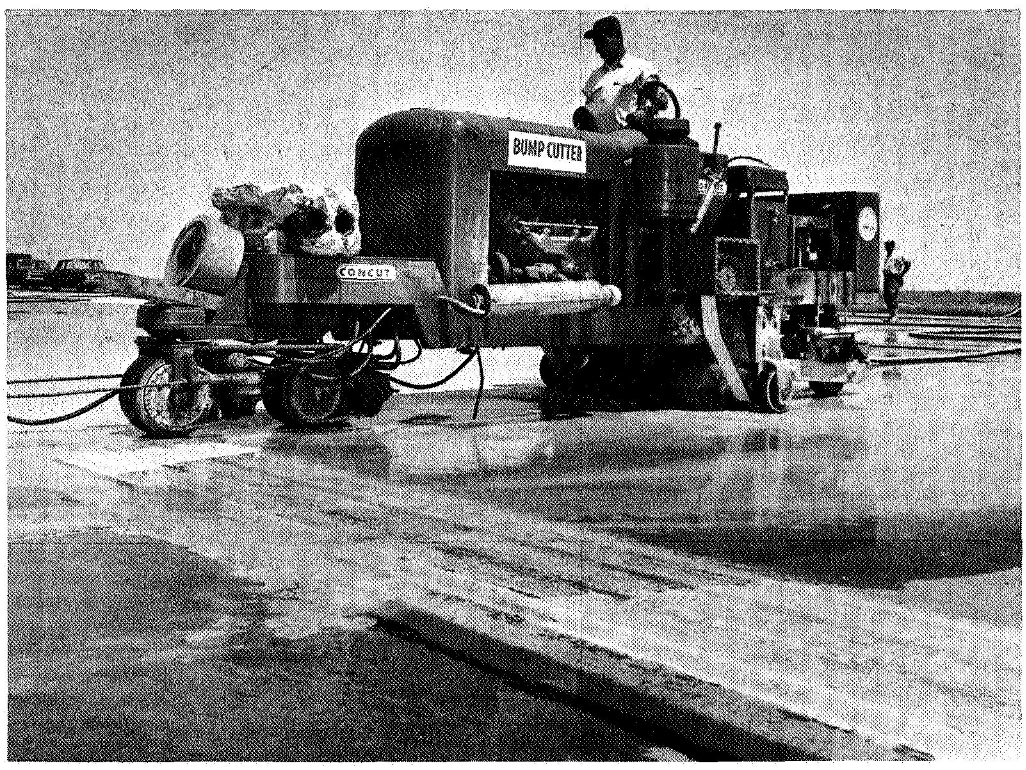

Figure 4.- Groove cutting at John F. Kennedy International Airport.

Figure 5.- Ungrooved areas left by peeling of paint and rubber deposits.