20. RUNWAY GROOVING AT KANSAS CITY MUNICIPAL AIRPORT

By Howard W. Willoughby

Kansas City Municipal Airport

SUMMARY

The runway grooving project at Kansas City Municipal Airport has now been completed for about 18 months. The problems encountered during construction and the results as observed by an airport operator will be discussed. Although some minor problems occurred during the grooving, the only major problem was control of the dust caused by the grooving machines. No major problems have been encountered insofar as runway maintenance is concerned after approximately 18 months of use. It would appear that runway grooving may have a place in the aviation industry for improving runway traction during inclement weather. No definite conclusions are being drawn from the observations of the project at Kansas City Municipal Airport. The results of this project should be evaluated with the results of projects at other airports in order to determine the effectiveness of the grooving and under what conditions grooving should be initiated at other airports.

INTRODUCTION

The subject of runway grooving on airports is important because grooving may have an effect on the length of runways recommended by the Federal Aviation Administration since additional runway is required when the surface is wet. While the theory of runway grooving has been accepted in the United States for some years, the effect of its application on commercial airports in this country has been unknown. Unknown areas include the effect of the grooves on aircraft vibrations and tire wear of both large commercial jets and general aviation aircraft and the effects of the aircraft upon the grooved surfaces of both asphalt and concrete paving. The grooving at Kansas City Municipal Airport offers a look at some of these problems in that both heavy jet aircraft and general aviation aircraft use the runway and both concrete and asphalt grooved surfaces exist on the same runway.

Before a definite decision was made to groove the runway at Kansas City Municipal Airport, many discussions were held with interested agencies involving the possibility of aircraft stopping in a shorter distance with a grooved runway and the effect the aircraft would in turn have upon the runway surface. A prime concern was the possibility that the grooving might cause rapid deterioration of the runway surface by spalling in the concrete areas or that the grooves in the asphalt might close up during the hot summer

months. If the grooving caused rapid deterioration of the surface, the runway would have to again be closed to be resurfaced. This closing would create not only a financial problem but an operational problem since there is only one runway available for commercial aircraft.

Once the Aviation Department of Kansas City was convinced that no adverse effect would occur because of the surface grooving, those other agencies concerned, specifically the airlines operating at Kansas City and the Federal Aviation Administration, were notified that the grooving would take place at Kansas City Municipal Airport. The grooving commenced on April 2, 1967, and was completed on May 26, 1967.

DISCUSSION

Kansas City Municipal Airport has one main runway, which is 7000 feet long. A shorter 5000-foot crosswind runway crosses the main north-south runway at its approximate midpoint at a 30^{o} angle. The crosswind runway has displaced thresholds at both ends of the runway so that its use for commercial aircraft is severely limited. With these runway conditions, the main problem in grooving was how to groove the runway without completely shutting down the airport for prolonged periods of time. While the crosswind runway could be used for general aviation and smaller commercial aircraft at times, the intersection area of the two runways including sufficient clearance on both sides of the intersection created a problem, in that at many times the airfield would have to be completely shut down.

The Aviation Department of Kansas City investigated the various types of equipment available for runway grooving and determined that the project could be completed within 60 days, working an 8-hour shift at night with approximately $5\frac{1}{2}$ to 6 hours available work time on the runway. The project was actually completed in 55 days.

The project officially began at 11:15 p.m. on April 2 and finished at 7:00 a.m. on May 26, 1967. The contractor worked approximately $5\frac{1}{2}$ hours per night. The basic plan was to close the runway for 30 minutes then open it for 15 minutes to allow traffic to take off or land. There were a few variations in the time on and off due to airline schedules, but basically no aircraft was forced to hold more than 30 minutes, nor was the contractor forced off the runway for more than 15 minutes at a time. Because of the slow travel speed of the cutting equipment and lost time in starting and stopping, a 1-hour cycle would have been better, that is, shutting down the runway for 45 minutes and then opening it for 15 minutes. Since flight departures tend to be on the hour, using intervals from the hour to 15 minutes after for arrivals and departures and from 15 minutes after to the hour for the grooving operation would have been better at Kansas City Municipal Airport.

The cooperation of the contractor, FAA tower, and airlines was excellent. The project was run on a schedule and everyone concerned adapted readily to the schedule and planned around it. There was an occasional interruption of the schedule due to weather or other unusual conditions but, in general, no problems existed insofar as scheduling was concerned.

The grooves were cut with a Christensen Diamond Service, Inc., concrete planner with 36 diamond cutting edges. The grooves were cut 1 inch on centers by 1/8 inch wide by 1/4 inch deep. It took approximately 12 minutes to cut a 130-foot groove across the runway in asphalt and close to 20 minutes in concrete. The grooves were cut 130 feet wide in order to leave a 10-foot shoulder on each edge for maneuvering the equipment. The equipment is heavy and equipped with steel wheels. The area at the edge of the runway becomes muddy from the large amount of water used, so it becomes impractical to run the equipment off the pavement to turn around.

The grooving started 600 feet from the south end of the runway and progressed north for 4500 feet. The north 1900 feet of runway were not grooved. Because of the unknown results of the method of cutting, the Aviation Department of Kansas City was skeptical about grooving the runway ends. It appeared that the most abuse to the grooves might occur while an aircraft was running its engines up prior to take-off. Because of the heavy vibrations and blast effect on the runway end, grooving was started just beyond the first touchdown marking. All landings during poor visibility and heavy rain are made to the south because of the instrument landing system. It was anticipated that an aircraft touches down and begins heavy braking about 2000 feet down the runway when landing south, so grooving was started at this point. It should be noted that the end result of this grooving was unknown and it was felt that a minimum area, consistent with being large enough to be practical, should be considered in the initial program.

The only major problem, which was a complete surprise, was the dust caused by the cutting. The dust turned to a slurry that was almost impossible to remove either wet or dry. The runway was washed, vacuumed, swept, and squeegeed but dust still remained when the surface dried. Both hand and machine operations were tried. It was impossible to remove the dust when dry by either sweeping or vacuuming. The dust is a very fine powder rather than granular. No particles or chips were seen during the operation. The dust, or powder, remained in the grooves, joints, and pores of the runway surface. Since no method was found to be effective in removing the powder, it must be a major concern to any airport attempting to groove a runway. It is believed that a large amount of high-pressure water would be the best solution to getting rid of the powder, but getting the water in large quantities to the runway can present a problem.

The danger of the powder appears to cause more of a psychological reaction than a danger to aircraft. The problem on take-off looks bad, but all dust is behind the aircraft.

On landing, dust or powder is kicked up from the reverse thrust. As long as the aircraft is moving at a relatively high speed, the dust stays well behind the aircraft. The real problem occurs when the aircraft is moving at a very slow speed with high reverse thrust. Undoubtedly, some powder is ingested at this time. This situation is accented with a four-engine aircraft that has drifted toward the edge of the runway because the edges are not blown clean by repeated take-offs as happens in the center of the runway.

Another problem area of the powder residue occurs at pavements that intersect at small angles. As the runway is washed, brushed, and so forth of residue, the residue spreads over other pavements off the runway being grooved. This causes the wet slurry material to spread over large areas before running off the pavement edge. In some areas, large amounts of slurry collect and create a problem of handling the material. Drainage, of course, has a major effect on how big a problem is created at intersections as well as on the runway itself. When powder accumulates at intersections and aircraft taxi over the area at low speed, the powder is blown loose. However, when an aircraft enters these areas at high speed with reverse thrust, large clouds of dust occur.

Possibly, arranging the grooving sequence to proceed from the high points on the longitudinal profile of the runway to the low points would have helped. The slurry would tend to run downhill over the ungrooved area rather than filling the freshly cut grooves. Starting the cuts at the runway center line and working toward the runway edges might also force the slurry to run off the runway.

Although not major, other unexpected small problems did occur. When the grooves were cut across cracks in concrete, the surface around the crack spalled. Some of the spalls were quite extensive, particularly when the angle across the cut was small. The cutting edges on the machine tend to tear out any loose concrete, and these areas had to be patched.

Another minor problem is the effect of the grooving on the asphalt overlay as it tapered or featheredged onto the concrete. Some of the asphalt came loose immediately. There is evidence that the asphalt was not properly bonded to the concrete in some areas. The Aviation Department of Kansas City now must watch the overlay in the area that feathers onto the concrete. There is no doubt that this has been weakened. What problem, if any, occurs remains to be seen. It is felt that some additional asphalt will break away, but no real difficulties are anticipated.

The results of the grooving as observed by the Aviation Department of Kansas City are considered very good. A James decelerometer in a vehicle is used to check braking action. The decelerometer shows readings of 20 or better under most conditions on the grooved pavement. Under extremely heavy rain, the reading may drop to 16 or 17. This is still good. The readings tend to remain fairly constant. Pilots have given braking

action reports of "good" under conditions that normally would have been "fair" or "poor" prior to grooving.

The difference in appearance of the runway surface is remarkable. During rain storms, the ungrooved section of the runway has a slick, wet appearance. The grooved section is dull in appearance. The water spray under the wheels is cut drastically in the grooved area. It is therefore believed that the grooving is beneficial on take-offs as well as landings. The grooves in the center of the runway stay clean because of engine blast effects and the washing action created by the tire pressure on the water in the grooves. From visual observation, listening to pilots' reports on braking action, decelerometer checks, et cetera, it appears that braking action is definitely improved by the grooved surface.

Kansas City Municipal Airport is fortunate in that there are two fire hydrants on the airfield that the contractor was able to use for a water supply. Aluminum pipe was laid from the hydrants to the runway. This was a long distance and created problems in that it crossed taxiways and, on occasions, the other runway. The water pressure was low by the time it got to the grooving machines, but using the pipes was better than hauling water in by truck. One incident happened because of this waterline. A C-46 taxied over the line on the taxiway and caused the tubing to collapse. The pilot had been informed that the taxiway was closed, the pipe was marked with barricades and lights, and it was daylight at the time. There was no damage except to the pipe and the contractor's temper.

Two minor problems occurred during the construction of the runway that can easily be eliminated. Two and sometimes three machines were used for the grooving operation. The machines were spaced approximately 100 feet apart down the runway and worked independently of each other. The first problem occurred as one grooving machine approached the area already grooved by the machine ahead of it. An attempt had been made to space the initial pass so that as the grooved areas met there would be no void left on the surface of the runway. This was a mistake since in most cases an overlap problem did occur, and rather than leave a void of something less than 3 feet on the runway surface, an attempt was made to overlap adjoining grooved areas. This became impractical, if not an impossible problem, in that cutting in the same groove on an overlap caused wider grooves to occur and eventually some deterioration occurred at these locations. Second, attempts were made to make the cuts across the runway in one continuous pass. This was not always possible and in attempting to aline the machines and cut in the same groove again, some uneven cuts in grooves occurred. It is faster and the grooving is as efficient if the new grooves are cut close to the ends of the existing grooves without any attempt to make the groove continuous.

The Aviation Department of Kansas City was concerned about what effect joint seal in the concrete areas would have upon the grooves. There was some concern that the seal would close the grooves and make them ineffective. This situation has not occurred. While the water may not drain as well from the runway because of the blocking of some of the grooves, the pressure of aircraft tires upon the grooves squeezes water out of the grooves so that the tires still ride on the surface of the runway. Water may remain in the grooves; however, it appears that this has no adverse effect upon braking action.

There was some concern that water freezing in the grooves during the winter might cause a hazardous runway condition. The reaction of the grooves to ice was more than satisfactory. While ice did form in the grooves, it appears that the weight and blast effect of the aircraft on the runway broke the ice from the grooves and had an effect of breaking up ice on the entire surface of the runway; however, that ice causes no problems would be a dangerous conclusion to make without further study. Further study should be made in this area to determine if there is a possibility that grooving will be an asset to winter operations and icy runways.

After approximately 18 months of operation, the asphalt area has shown practically no deterioration. The grooves are clean and show no signs of rubber buildup or closing due to braking action. There is no chipping, spalling, or loss of aggregate in the asphalt areas. If there is any deterioration in the asphalt pavement, it is insignificant and cannot be seen by casual observation.

There is some deterioration in the surface of the concrete pavement; however, it is difficult to determine specifically how much of this is a result of the grooving. There are two deterioration processes taking place. First, there is a noticeable increase in aggregate pop out in the surface of the concrete; however, at this time it is not considered to be a serious problem. In all probability, the cutting action of the saws has loosened aggregate next to grooves, and this has worked loose due to freeze-thaw cycles and the traffic of aircraft over the loosened aggregate. It should be noted that there are also similar pop outs in the ungrooved portion of the runway; however, not to the extent that there are in the grooved area. Second, there is a very definite increase in spalling along pavement cracks in the concrete area. The same situation does not exist in the asphalt areas. It is impossible to determine if the concrete is spalling more than it would have if the grooving had not been accomplished. At this time, it is not causing any serious problems insofar as maintenance of the surface is concerned.

After 18 months of operation, the Aviation Department of Kansas City can say that it is favorably impressed with the results of the grooving at Kansas City Municipal Airport. Experience here has shown that grooving of asphalt surfaces is causing no deterioration of the runway. The grooving of concrete surfaces may cause a problem depending on the condition of the existing pavement. In all probability, any old surface

would show signs of aggregate pop out or numerous cracks which deteriorate more rapidly when grooved. It would appear that the results of grooving would be worth the possibility of increased maintenance to the surface of this type of runway.

The runway at Kansas City Municipal Airport was grooved 4500 feet in length and 130 feet in width at a cost of just under $90 000. It should be noted that the contractor had to work under severe handicaps and that he was limited in his time on the runway. The work was done at night and 7 days a week until the job was completed. The contractor was forced to contend with a continuous operation which required him to move equipment on and off the runway at 30-minute intervals. If a contractor were allowed to work on the runway a continuous shift without paying premium time for weekends and holidays, in all probability, his costs would be cut considerably. Those agencies attempting to determine a price for future grooving should not attempt to compare various prices without knowing the details of the operation under which the contractor was subjected.

CONCLUDING REMARKS

It would appear that there is a place for runway grooving either in the manner constructed at Kansas City Municipal Airport or some variation thereof. While there may be problems in accelerated runway deterioration, it seems that the overall results will more than compensate for this slightly accelerated deterioration of the surface of the runway. There are problems in construction, primarily in time and method of construction, as well as the problem of handling the slurry formed by the dust. Continued work on the dust problem will yield a solution.

It is felt that those interested in runway grooving should determine a method of grooving runways while they are being constructed. This would be particularly true in concrete runways since a constructed groove will in all probability tend to deteriorate the runway surface less rapidly than a sawed groove. There appears to be no feasible way at this time to construct a groove in an asphalt runway as it is being laid. There is the possibility of sawing the asphalt immediately after it is laid. This method will tend to cut construction costs of the grooving since the fresh asphalt will cut easier; however, the end product may not be satisfactory. When an economical method of constructing grooves has been obtained, all runways, regardless of length, should be grooved.

Grooving an existing operational runway will create some operational problems during the construction that must be handled on a local level. As more runways in the United States are grooved, some of the existing problems will be answered and undoubtedly some new problems will be turned up. It behooves each agency contemplating a runway grooving project to gather all information available from other airports. Unfortunately,

most of the information available from contractors has been obtained by hearsay or roadway projects. The problems encountered on an airport have no relationship to most contractors' previous experience.

In conclusion, it is believed that runway grooving has its place in the aviation industry; however, some national or international agency must determine what place this is.