IMPROVED METHODS FOR CONSTRUCTION AND MAINTENANCE OF RUNWAY PAVEMENT SURFACES

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Since the advent of turbojet operations at airports, the Federal Aviation Administration (FAA) has been involved through research and experience to improve the construction standards of pavements. This includes the pavements structural capacity as well as its surface integrity for effective braking action. To improve on the latter, FAA has promoted grooving as one of the highest priorities to be considered for improving braking friction and mitigating hydroplaning. Today, almost 100 runways in the U.S. are grooved. Another improvement developed through research and experience is a porous friction course overlay. There are some 30 runways constructed with this type overlay. In addition a task group within FAA has prepared a list of some 200 runways which are potential candidates for grooving.

Current FAA Guidance

In 1975, an advisory circular, Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces (1) was published to provide airport operators, engineering consultants, and maintenance personnel guidance on methods that can be used to maintain airport pavement surface friction characteristics. The circular covers various treatments for asphaltic and portland cement concrete pavements; discusses various types of friction measuring equipment and describes in detail a specific type; identifies parameters for pavement surface evaluation; establishes procedures for surveys, data acquisition; discusses pavement mix design and material characteristics for skid resistant pavement surfaces; describes construction methods for various surface treatments and maintenance methods; and identifies airport managers' responsibility in maintaining pavement surfaces. Also included in the appendices of the circular are procedures for measuring pavement surface texture depth, and specifications covering grooving, porous friction course, and asphaltic emulsion slurry seal surface treatment.

Implementation

The implementation of a program to reduce the potential of aircraft sliding off wet runway pavements is strictly a voluntary one, as there are no Federal Aviation Regulations covering this aspect at the present time. The advisory circular is designed to fill the gap until such time as it is deemed necessary to incorporate the guidance into a Federal Aviation Regulation.

Eligibility

The FAA encourages construction of skid resistant surfaces by the issuance of grants under the Airport Development Aid Program (ADAP). The requirements for eligibility are given in Federal Aviation Regulations (FAR) Part 152 (2). Another FAR, Part 139 (3) covers the Certification of Airports. Under Part 139.83, Pavement Areas, are specific items the airport operator is responsible to meet. One of the items of chief concern are rubber deposits which cause runways to be very slippery when wet. The rule does not provide a means to determine when rubber deposits are hazardous, just states they should be removed by operational considerations.

When the rule was being drafted, the requirement for measuring runway slipperiness was included. However, in the absence of the development of an approved standard for measuring the coefficient of friction, the requirement was deleted from the final rule.

The requirements for eligibility are given in the Federal Aviation Regulation (FAR) Part 152 which is being revised and will state that:

"New runway pavements, overlays and leveling courses are eligible under ADAP. Overlays are considered eligible only when the structural integrity of the existing pavement does not provide adequate support for aircraft operations. Leveling courses are eligible when used to correct major surface irregularities in pavements that are structurally adequate. Final constructed pavements must have adequate skid resistant surfaces and drainage to mitigate hydroplaning. Porous friction course and grooves constructed on new or old pavements for the purpose of providing skid resistant surfaces on runways at general aviation and small hub airports are eligible. Seal coats applied as normal maintenance for crack sealing, refilling joints, prolonging pavement life, or rejuvenating old pavement surfaces are ineligible. Seal coats to provide skid resistance are not eligible where the sponsor or airport operator has failed to remove rubber deposits as part of a responsible maintenance program."

Management Responsibility

The airport owner must make several judgmental decisions in his efforts to provide and maintain adequate pavement surfaces. He must anticipate the effect of weather conditions on the surface of the pavements; he must choose the most effective surface texture to be applied to both existing and new pavements considering the weather conditions, type of aircraft, and number of aircraft operations; he must develop a proper maintenance program to ensure a safe operational surface; he must continually monitor the pavement surface friction characteristics of his pavements in order to determine the loss of effective braking action; last, but by no means least, he must budget funds for maintaining antiskid pavement surfaces. The purpose of Advisory Circular 150/5320-12, Methods for the Design, Construction and Maintenance of Skid Resistant Airport Pavement Surfaces, is to provide guidance to the airport owner in making these decisions.

Construction Techniques for New Runways

The airport owner can improve the braking action on runway pavements by saw-cut or plastic grooving, wire combing, constructing a porous friction course overlay, or using friction seals.

Grooving

Grooved pavements were a British innovation first tried in 1956 at several aerodromes in England. There are approximately 100 runways grooved in the United States, and the first major airport to groove a runway was Washington National Airport.

Tests conducted at the National Aeronautics and Space Administration (NASA) Wallops Station (4) of 19 groove configurations showed the 1/4" x 1/4" x 1" groove pattern offered the best aircraft tire braking capability. Based on the results of this test program, FAA selected the 1/4" x 1/4" x 1-1/4" groove configuration as its standard. The 1-1/4" spacing was selected to provide a minimum 1" land area between the grooves. Grooving can be accomplished in two ways: sawed in existing or new pavements or formed in concrete while it is still in the plastic state. Sawing is the only satisfactory method which has been developed for grooving asphaltic concrete runway surfaces.

Sawed Grooves

In the United States, airport runways are grooved by sawing the grooves transversely; that is, the grooves are cut crossways to the direction of the aircraft motion. The groove geometry is specified in the following manner; the width and depth measurements of the groove are given first, followed by the pitch, the distance between the grooves, center to center. Grooves are cut in pavements by means of a diamond-studded saw technique or by a flailing technique using hardened steel cutters.

As a preliminary to design, a pavement evaluation survey should be made of the entire area to be grooved. Depressed areas and badly cracked and/or spalled areas in the pavement should not be grooved until such sections are repaired or replaced.

If the survey shows that the existing pavement is not suitable from a strength standpoint, an overlay, either flexible or rigid, will be required. Costs for sawed grooves range from 8 to 15 cents per square foot. Generally, it is cheaper to groove in asphaltic concrete pavements by some 3 to 5 cents per square foot when compared to portland cement concrete pavements.

Plastic Grooves

The Belgians and the British were probably the first to develop equipment for forming grooves in plastic concrete. The advantage of plastic grooving is that the grooves are formed while the concrete is in the plastic condition and is an integral part of the paving train operation. The cost for constructing grooves in plastic concrete is significantly less than sawed grooves.

Paving contractors in the U.S. have constructed grooves in plastic concrete by several methods: one method is a cylindrical tube with ribs on the outside to form the grooves as it is transversely rolled over the plastic concrete pavement; another is a steel-tined comb for forming the grooves in the plastic concrete. There are over ten runways that have been plastic grooved. In the UK, the British use a flat ribbed plate that is vibrated across the pavement. This method simulates closely the saw-cut finish. Another method used is a wire comb which simulates grooves in the plastic concrete pavement. The wire comb method is one of the successful methods used in the U.S. The wire comb provides a configuration that is 1/8" x 1/8" x 1/2". Experience has been very favorable at ten airport runways in the U.S. This technique provides an excellent braking surface with minute channels for water to escape under aircraft tires. The cost for constructing plastic grooves and wire comb surfaces is minimal.

Porous Friction Course

Highway departments of California, Nevada, New Mexico, Utah, Colorado, and Louisiana have been successfully using friction courses for several years and for many miles of highways. The UK initiated the specification and constructed the first porous friction courses for airport runways.

There are 27 runways constructed with porous friction course overlays, jointly funded by FAA and the airport owners under FAA's Airport Development Aid Program (ADAP). The performance of these surface treatments has been excellent. PFC costs range from 8 to 23 cents per square foot.

Other Surface Treatments

The FAA recognizes the need for general

aviation and smaller hub airports to improve the surface texture of their runway pavements. The majority of these runways are not suited for grooving or PFC construction without major reconstruction prior to such surface treatments or because of lack of funds for grooving or PFC. For these runways, FAA recommends using asphaltic emulsion slurry-seal coats or a wire comb finish. When applied for the purpose of increasing skid-resistance, these types of surface treatments are eligible for Federal participation under ADAP.

Restoration of Existing Runways

Tests have shown that wet runway areas contaminated by heavy rubber deposits and/or oil and jet aircraft exhaust deposits provide approximately one-half the braking effectiveness of the same contaminated areas when dry. These contaminated areas very likely have contributed to poor aircraft stopping ability on wet runways. In order to maintain a runway that has good antiskid characteristics, airport owners must determine how, when and where maintenance should be performed. This can be done by conducting periodic friction surveys.

Friction Survey Procedures

Before friction measurements are made, a visual inspection of runway surface conditions should be conducted to determine the limits of rubber deposits, areas of ponding, and other deficiencies. These areas can be designated by runway stationing using existing horizontal control. They should be identified on a runway plan before the friction measurements are taken.

Location of Test Runs

Test runs should be made approximately 10 feet from the runway centerline and should encompass the full length of the runway minus the 500 feet acceleration/deceleration distances at runway ends. Subsequent test runs should be run at the same location to insure realistic comparisons can be made with previous test run data.

Marking Changes in Runway Pavement Surfaces

Before making a test run, traffic cones should be placed adjacent to locations at the beginning or end of areas where there is a visual change in surface characteristics. This would include areas of rubber deposits, change in pavement types, areas of ponding, and runway intersections. The traffic cones will assist the tow vehicle operator in determining when to activate precoded Mu-Meter event markers.

Test Runs Using Self-Watering Equipment

These are the test runs normally used for calibrating runway pavement surface conditions. They will enable the airport operator to determine what remedial action is required as set forth in paragraph on measurement parameters.

Test Runs on Dry Pavement

When surface friction of a runway is being measured for the first time, a test run of the dry pavement surface should be made before the test run using the self-watering equipment for comparison purposes. This will enable the airport operator to determine the extent of the friction loss due to wet pavement. Test runs on dry pavements do not need to be made each time a wet pavement test is conducted. Dry runs should be made often enough to check wear of the pavement surface due to traffic.

Test Runs During Rainfall

If runways have pavement irregularities such as ruts or depressed areas which retain water during rainfall, they should be subjected to surface friction test runs. Because the tests will be run during rainfall, the use of self-watering equipment will not be required. The purpose of conducting tests during rainfall through these areas is to check the relative loss of friction. The depressed areas could cause aircraft directional control problems, hydroplaning, or engine flameouts.

Test Runs on Runway Paint Markings

These areas should be tested occasionally using self-watering equipment to determine if they are slippery when wet.

Data Acquisition

The graph strip chart provides a permanent record for the friction values of a particular runway surface. The gear reduction unit that gives 1 inch equals 150 feet should be used. As such, proper identification of all field observations should be made directly on the graph strip chart immediately upon completion of each test run. This can be done by establishing an event mark code for each runway surface condition encountered during the survey.

Graph Chart

It is important that the stationing of all significant observations be shown directly on the graph strip chart for future reference. The graph strip chart obtained in the next survey can then be compared by the airport operator with the previous test run. The airport operator should emphasize to the test personnel the importance of conducting the survey at the same location as the previous test run, so proper comparisons can be made.

Pertinent Test Information

Certain information should be written on each graph strip chart for record. The following items should be considered: airport name, location, survey date and time, weather, runway designation, and type of pavement.

Measurement Parameters

Several conditions that influence the friction characteristics of wet pavement surfaces are texture depth, contaminants, paint markings, pavement abnormalities, and the overall effective friction level for the runway length. The airport operator should evaluate each of these conditions by the following parameters:

Texture

The first condition for consideration is the average texture depth of ungrooved pavements. Research and experience have shown that pavements with average texture depths near 0.020 inches often have very low coefficient of friction values in the wet condition. The following textural parameters are offered for consideration.

When the AVERAGE TEXTURE DEPTH is equal to or less than 0.020 inches for more than 50 percent of the runway surface, improvements should be made to increase the surface texture to an acceptable level of at least 0.050 inches. Suggested methods for improving texture include grooving, porous friction course, and aggregate seal coats. Average texture depths for pavements can be measured by using the NASA grease-smear method.

When the AVERAGE TEXTURE DEPTH is equal to or greater than 0.050 inches, no further texturing effort is required.

Contaminants

The second condition affecting the surface friction characteristics of runway pavements is rubber deposits and dust particles accumulating over a period of time. One of the main problems facing the airport sponsor concerning the condition of runway pavement surfaces is the rubber deposit buildup. The following parameters are given to assist the airport operator in making the decision on when it is necessary to remove the rubber deposits from the runway pavement surface.

When the AVERAGED MU VALUE within the contaminated area is 0.49 or less, for a distance of 500 feet or more, the entire contaminated area should be cleaned.

When the AVERAGED MU VALUE within the contaminated area is 0.29 or less, for a distance of 250 feet or more, the entire contaminated area should be cleaned.

When the DIFFERENCE IN MU VALUES either between the uncontaminated and contaminated areas or within the contaminated surface itself is 0.25 or greater, for a distance of 250 feet or less, the entire contaminated area should be cleaned.

Paint Marking Areas

A third consideration affecting the skid properties of a pavement is the large painted areas, such as runway markings. The airport sponsor should occasionally check the friction values of these areas according to the following parameter.

When the MINIMUM MU VALUE over the length of the runway marking is 0.25 or less and/or DIFFERENCE MU VALUES between the unpainted and painted surfaces is 0.25 or greater, the painted areas should be completely removed and repainted (without glass beads) in a striated pattern.

Pavement Abnormalities

Runways that have depressed surface areas are subject to ponding during periods of heavy rainfall. Since these ponded areas occur primarily in the aircraft wheel path areas, there is a potential for engine flameout and hydroplaning. For this reason friction surveys should be conducted during rainfall with the Mu-Meter (without the self-watering device) through the puddled areas to detect the relative loss of friction for these conditions. The self-watering device, in this case, is not capable of relating accurately to the ponding situations. The following parameter is offered for consideration.

When the DIFFERENCE IN MU VALUES between the flooded depressed areas and the surrounding pavement surface is 0.25 or greater for distances exceeding 100 feet, or if there is a repetition of ponded areas, corrective action should be taken. Depending on the extent and circumstances of the depressed areas, minimal normal maintenance to a completely new overlay may be required.

Minimal Average Friction Requirement for Runway Pavements

After the runway has been cleared of contaminants, the AVERAGE WET MU VALUE should not be less than 0.50 for each 1,000 foot increments of the runway length. If any increment does not meet this requirement, the entire runway should be corrected.

Cleaning Methods

There are several acceptable methods available to the airport owner for removing contaminants on runway surfaces. They are chemical, high-pressure water, high-velocity impact, and mechanical methods.

Chemical

Chemical solvents have been successfully used to remove contaminants on runway pavements. They must, however, be biodegradable, and washed off the pavement after use so that the dillutant will not harm surrounding vegetation or drainage systems, or pollute nearby streams and wildlife habitats. Chemical costs average around 8 cents per square foot.

High-Pressure Water

Within the last few years, a new method for removing contaminants on runway surfaces, called high-pressure water (HPW), has been used successfully at airports. The principle of this method is very simple. A series of very high-pressure water jets are aimed at the pavement surface and blast off the contaminants. This technique is economic, environmentally clean, and effectively removes all deposits from the pavement surface in minimal downtime to the airport sponsor. Most HPW equipment used today operates between 3000-6000 psi and is capable of pressures exceeding 10,000 psi if needed. HPW costs range from 2 to 4 cents per square foot.

High-Velocity Impact

A relative newcomer in cleaning airport runways, high-velocity impact, looks very promising. The principle of this method uses abrasive particles thrown at high centrifugal force, impacting on the pavement, thus blasting contaminants from the surface. The machine is environmentally clean in that it is self-contained; it collects the abrasive particles and contaminants, removes contaminants, and recharges the particles for use again. Although new to runway cleaning, the method has been used quite successfully in cleaning structural members for many years. It is also used for texturing surfaces for architectural effects.

Mechanical

Mechanical surface grinding machines have been successfully used to remove heavy rubber deposits from runways. They are also used to remove high areas on pavement surfaces such as bumps or at joints where slabs have shifted or faulted.

Improvement of Texture and Drainage

Existing pavements may or may not have surfaces that are suitable for sawing grooves. A survey should be conducted to determine if an overlay or rehabilitation of the pavement surface is required before grooving operations begin.

Reconnaissance Survey

A thorough survey should be made of the entire width and length of the runway. Bumps, depressed areas, bad or faulted joints and badly cracked and/or spalled areas in the pavement should not be grooved until such areas are adequately repaired or replaced. To verify the structural condition of the pavement, tests should be taken in support of the visual observations.

Surface Treatment

If the survey shows that only minor corrections to the pavement are required, then grooves can be saw-cut, or a porous friction course overlay constructed. If the survey shows that the existing pavement is not suitable because of either surface defects or from a strength standpoint, an overlay, flexible or rigid will be required. Either a PFC overlay or saw-cut grooves can be constructed to provide good skid resistant/drainage surface.

Status of Research

Several research projects are now underway to help airport owners in providing pavement surfaces for safe aircraft operations. In 1971, the FAA contracted the U.S.A. Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi, to prepare Item P-402, Porous Friction Course, for use in this country. Two research reports (5,6) have been published, and a final specification is now being prepared for publication. Another study underway at U.S. Naval Air Station at Lakehurst, New Jersey, is the optimization of tire cutting and tire life on grooved runway surfaces, as well as the cost/benefit analysis of constructing a least cost groove configuration.

A study just completed evaluated the effect of periodic cleaning of contaminants by the HPW technique on runway surfaces (7). The results of the study revealed that no deterioration or loss of friction due to the HPW technique was observed during the tests. Also, the HPW was very effective in removing contaminants and paint areas, if required.

Research and experience have shown that grooved pavement surfaces significantly increase surface friction, improve the braking action and directional control of aircraft, retard accumulation of rubber deposits, and lessen the potential for hydroplaning. Maintenance personnel have reported that the rolling action of aircraft tires on thin ice layers tends to break up the ice that forms on grooved runway surfaces. This action gives better control of the aircraft on icy runways. Although grooving of airport runways is the most effective method of providing good antiskid properties during adverse weather conditions, the aviation community will continue to evaluate other methods as well. PFC has also proved effective in dissipating surface water and breaking up thin films of ice.

References

1. Anon: Methods for the Design, Construction and Maintenance of Skid Resistant Airport Pavement Surfaces, AC 150/5320-12, FAA, June 30, 1975.
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3. Federal Aviation Regulations, Part 139.
4. Anon: Pavement Grooving and Traction Studies. NASA SP-5073, 1969.
5. Thomas D. White. Porous Friction Course, FAA-RD-73-197 February 1975.
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7. Charles Grisel. A summary of Runway Friction changes due to High-Pressure Water-Jet Cleaning Operation at Four Airports, FAA-RD-75-218, January 1976.