TRANSPORT CANADA RUNWAY COEFFICIENT OF FRICTION OPERATIONAL MAINTENANCE PROGRAM

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The objective of this program is to ensure the provision of safe airport runway operating conditions for efficient air transportation in Canada. This is being accomplished by the establishment of standards covering minimum coefficient of friction for runways, procedures and instruments for measurement and by periodical assessment of runway surface conditions. These standards take into account the runway length, runway elevation, wind and the type and weight of scheduled aircraft. The instruments used in measuring runway coefficient of friction were tested by the International Civil Aviation Organization on selected pavements, representing most typical runway conditions, and have useable correlation with aircraft performance for certain aircraft type. During winter months, the runway coefficient of friction is measured and reported on a routine basis as part of snow removal and ice control using James Brake and Tapley Meter Decelerometers at designated airports. Although no comparable program of operational measurement and reporting during rain storms exists in the summer, an ongoing evaluation program of runway calibration under wet conditions is in effect. The Skiddometer BV11-2, a continuous measuring and recording instrument, is used to measure the runway coefficient of friction in conjunction with a self-watering system. The frequency of runway evaluations is based upon the annual number of scheduled aircraft movements and the class of aircraft. A procedure is being established by which air carriers will be notified of runways which lie near the borderline of the minimum established coefficient of friction value. Provision is made to initiate corrective action for those runways whose coefficient of friction under standard wet conditions, falls below the minimum safe values. Remedial measures to restore runway coefficient of friction are dictated by the causes of slipperiness such as rubber contamination, polishing of the surface texture or insufficient surface draining of water. Effective techniques to implement corrective action range from removal of rubber deposits by high pressure water or lateral corrugation, retexturing polished surfaces by impact hammering or grooving to improve lateral drainage of water.

Runway Coefficient of Friction Operational Maintenance Program

The Canadian airport system illustrated in Figure 1 contains 875 licensed airports. The Air Administration of Transport Canada owns and operates 110 of the major airports in the system and owns an additional 66 which are operated by municipalities. As a result of the need for a comprehensive and co-ordinated approach to the provision of airfield pavements at these airports, a pavement management system has been developed. This system involves the evaluation of many activities and parameters related to pavement design, construction, operations and maintenance, from which the average performance and service life estimates can be established and comparisons of design alternatives made. The main purpose of the pavement management system is the provision of safe and efficient runway surfaces which are compatible with current and future aircraft operating requirements. (9,10,11,12,13,14,15).

One very important parameter in runway pavement is the surface coefficient of friction. Runway coefficient of friction requirements vary with the length of runway, the elevation of the runway above sea level, the wind, the type and weight of aircraft using the runway. Long runways, situated near sea level, and used by light aircraft can tolerate a much lower level of safe coefficient of friction than shorter runways, located at higher elevations and catering to large aircraft.

It is possible to calculate the minimum average runway coefficient of friction for each runway based on the runway length, the demonstrated landing distance of an aircraft and a certain factor of safety. However, there are two drawbacks to this approach. Firstly, this theoretical value of the minimum average coefficient of friction would have to be revised as different aircraft are scheduled into service on the same runway. Secondly, since runway lengths are based on the take-off requirements of an aircraft which are much longer than the landing distance requirements, the minimum average acceptable coefficient of friction on most runways would be quite low, in fact below the coefficient of friction required to withstand a serious crosswind condition.

It is possible to set values of the minimum coefficient of friction of a runway at the level higher than the one produced from the aircraft's demonstrated ability to stop on a slippery surface in zero wind conditions. A factor in selecting the minimum coefficient of friction value should take into consideration the prevailing crosswind conditions.

The coefficient of friction of a runway is not constant but varies seasonally on a short term basis throughout its life. As the runway accumulates rubber deposits and is polished by the action of snow removal equipment, the two touchdown zones become more slippery than the rest of the runway under wet conditions. Short slippery runways present a potentially hazardous operating condition.

Transport Canada Coefficient of Friction Standards

It is the policy of Transport Canada to provide airport runway surfaces which will permit safe operations for designated aircraft at all times; to measure and report runway coefficient of friction and surface conditions to airlines upon request during winter season at selected airports and to monitor the change in runway coefficient of friction so that corrective action can be taken before hazardous conditions will arise.

The objective of Transport Canada is to provide for operational purposes a minimum average runway coefficient of friction value of 0.65, under normal wet conditions, as measured by the Skiddometer BV 11-2.

Whenever the average runway coefficient of friction measurement under normal wet conditions falls into the range of 0.65 to 0.50, corrective action to restore the average coefficient of friction shall be planned.

Whenever the average runway coefficient of friction measurement under normal wet conditions falls into the range of 0.50 to 0.40 the operators shall be advised.

Whenever the average runway coefficient of friction measurement under normal wet conditions falls below 0.40 corrective action shall be taken to restore it.

Whenever local areas of runway surface exceeding 150 m in length have an average coefficient of friction under normal wet conditions of less than 0.30, corrective action shall be taken to restore it.

For further details, see (1).

Acceptable Methods of Runway Coefficient of Friction Measurement

About 10 years ago, Transport Canada started to explore better methods of measuring the coefficient of friction of runways instead of accelerating a pick-up truck and putting the brakes on. As a result of this effort, the James Brake Decelerometer was adopted as the standard instrument for measuring the braking action of runway surfaces covered in whole or in part with solid state contaminant such as compacted snow and ice. In the late 1960's, it became the policy of Transport Canada to measure and report runway coefficient of friction on a routine basis using the James Brake Decelerometer during the winter season at a number of designated airports.

In the early 70's an operational circular was promulgated by the Civil Aeronautics Directorate of Transport Canada explaining the application of JBI information to pilots for use in flight planning and during take-off and landing operations. Concurrent with our efforts to provide and disseminate runway condition information to users during the rigours of Canadian winters, the other potential hazard of operating on runways during summer rain storms came into focus triggered by several runway overruns in the late 60's which were attributed to low wet friction characteristics.

At about this time several manufacturers around the world had placed on the market instruments which were designed to measure the coefficient of friction of wet runways and even detect hydroplaning conditions. We participated with International Civil Aviation Organization, National Aeronautics and Space Administration, Federal Aviation Administration and United States Air Force teams evaluating the merits of several of these devices, notably the Diagonal Brake Vehicle, Mu-meter, Skiddometer and a Tapley Meter and have during the past five years tested these units on a cross-section of Canadian airports under both summer and winter operational conditions. For further details, see (2) and (3).

As a result of this evaluation, Transport Canada has adopted the Swedish Skiddometer Model BV11-2 as the standard instrument for evaluation of runway coefficient of friction characteristics under wet surface conditions. We have also adopted the use of Mu-meter Model ML400 as the backup instrument whenever the Skiddometer is not available for this purpose.

The James Brake Decelerometer remains the approved instrument for use in measuring coefficient of friction under solid state conditions during the winter season on an operational basis. It is now being supplemented with Tapley Meters which are identical in operation to James Brake Decelerometer. Over 90 airports at present are served with one of these instruments in Canada.

Transport Canada National Runway Measurement Program

The purpose of this program is to conduct periodical assessment of runway coefficient of friction statistical data in order to produce an inventory of runway coefficient of friction so that any change in conditions affecting the safety of aircraft operations can be detected and corrective action planned before a dangerous condition will develop. For further detail, see (4) and (5).

This program was launched in May 1976 and is divided into 3 phases:

Phase 1 - Initial application (1976/77)
Phase 2 - Periodic assessment of runway coefficient of friction
Phase 3 - Notification and corrective action

Phase 1 activities will lead to the establishment of the scope and extent of Phase 2 program, which will be of an on-going nature. Phase 3 action will take place on an as required basis when substandard runways are detected.

Phase 1 - Initial Application (1976/77). Initial application 1976-77. The following airports have been surveyed based on the parameters shown in (1.) to (4.) below:

Table 1. 1975 annual aircraft movement

Airport	Total	Itinerant	Jets
Toronto International	238,000	228,000	157,000
Dorval International	192,000	186,000	127,000
Mirabel International (December only)	4,000	4,000	2,900
Ottawa International	207,000	77,000	43,000
Quebec City	158,000	78,000	17,000
Hamilton	203,000	63,000	5,000
London	122,000	52,000	6,000
Halifax International	78,000	41,000	24,000

This program was executed along the following lines.

1. Coefficient of friction was measured under dry and wet conditions.
2. The age of the runway pavement surface at the time of friction measurement is determined.
3. Determine total accumulated aircraft movements since the present runway pavement surface was constructed for each runway measured.
4. Establish the relationship between the coefficient of friction, the rate of friction deterioration with surface age and aircraft movements.
5. Determine the usefulness of stereo photography in conjunction with coefficient of friction measurements using the Skiddometer.

See Fig. 2 for a typical coefficient of friction performance chart.

Phase 2 - Periodic Assessment of Runway Coefficient of Friction. National periodic survey of runway coefficient of friction will be established based upon the following criteria:

1. Select airports whose runway pavement friction will be measured periodically based upon the criteria of paved runway and certain minimum jet traffic.
2. Determine the frequency of runway friction measurements based upon the criteria of the number of aircraft movements.
3. Determine the agency that will conduct this program.
4. Estimate the annual cost of this program.
5. Implement the program that is determined as the result of findings of Phase 1 Program discussed above.

Phase 3 - Notification and Corrective Action. Notification and corrective action:

1. Identify runways surveyed to data that are critical in terms of deteriorating surface friction.
2. Notify air carriers of these runways including the estimated reduced landing performance likely to be expected under wet conditions.
3. Identify the causes of slipperiness of these runways.
4. Prescribe corrective action to restore the runway friction and estimated cost.
5. Establish a priority schedule for implementing corrective action based upon the following factors:

(i) the rate of friction deterioration
(ii) the jet traffic movement
(iii) runway category
(iv) runway length in relation to the scheduled aircraft landing requirements
(v) climatic conditions of frequency, duration and intensity of rainfall
(vi) the age of the pavement surface
(vii) program planning in respect of overlay construction
(viii) projected changes in future runway use - change in traffic and/or scheduled aircraft type
(ix) record of aircraft incidents attributable to slippery runway conditions

6. Implement corrective action as required.

See Fig. 3 for a typical relationship between the runway average coefficient of friction and accumulated itinerant aircraft movements.

Approved Methods to Restore Runway Surface Conditions to Acceptable Limits

The three main causes of slipperiness of runway surfaces during rain were identified as follows:

1. Water ponding due to poor drainage.
2. Rubber accumulation at both touchdown zones.
3. Polishing of the surface brought about the use of steel bladed snow removal equipment.

Approved methods to relieve water accumulation during rain are:

1. Resurface the runway by means of an overlay thereby re-establishing the maximum allowable lateral slope and surface drainage.
2. Introduction of lateral drainage channels by such means as grooving, lateral corrugation.

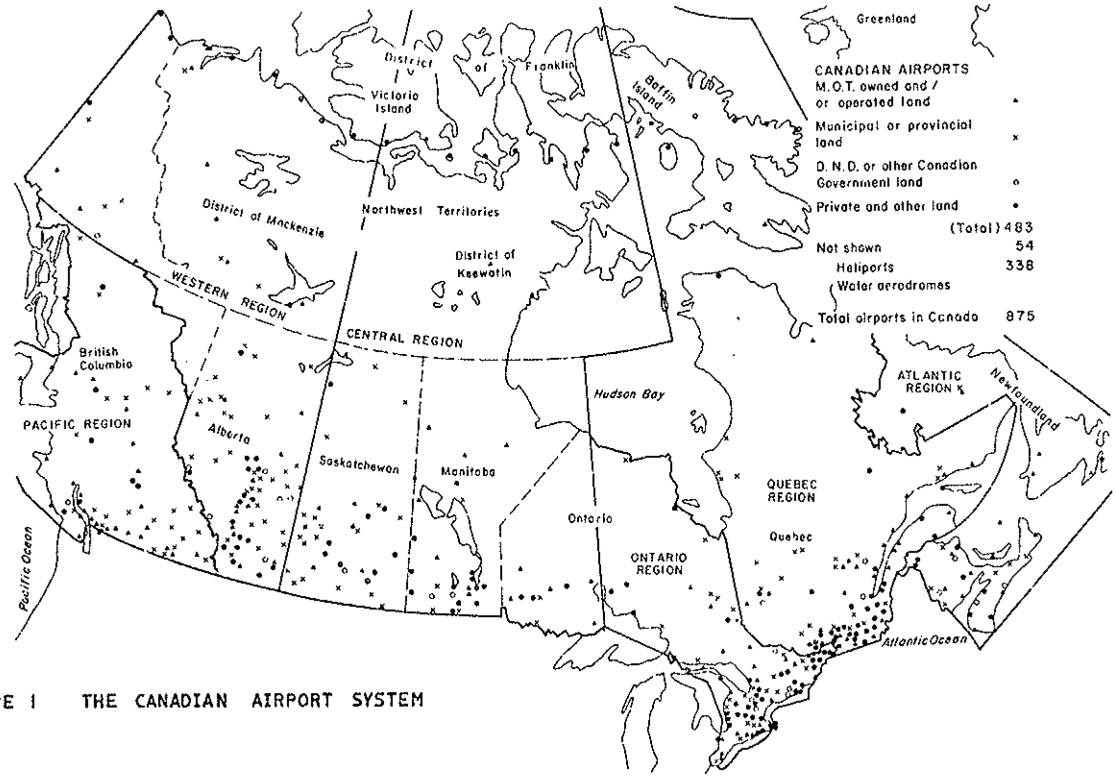

FIGURE 1 THE CANADIAN AIRPORT SYSTEM

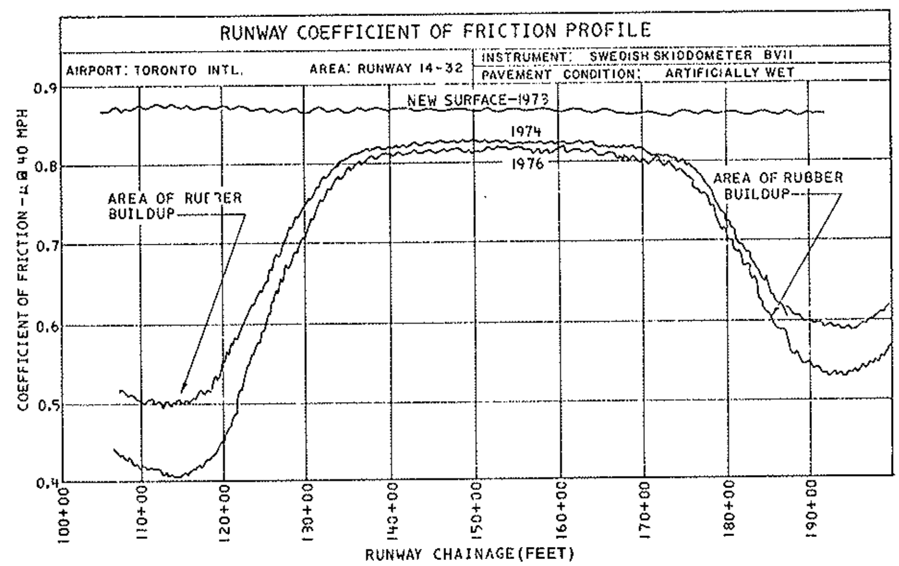

FIG. 2 TYPICAL COEFFICIENT OF FRICTION PERFORMANCE CHART

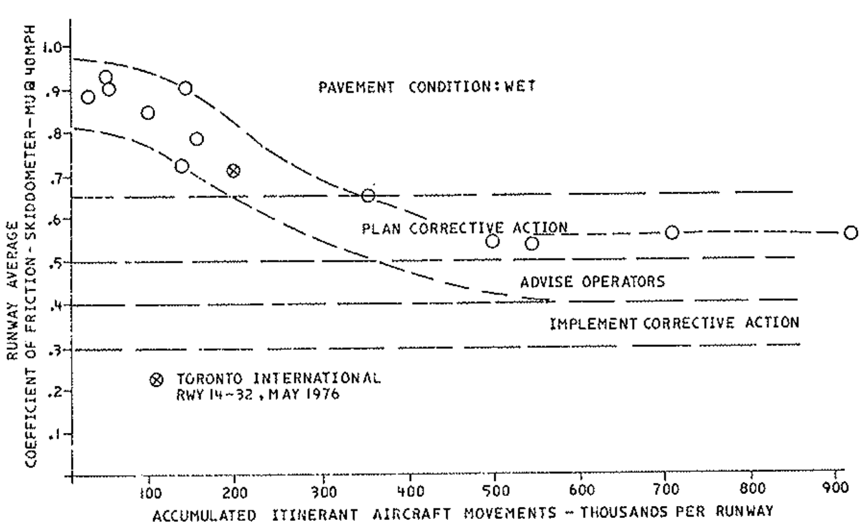

FIG. 3 RUNWAY AVERAGE COEFFICIENT OF FRICTION VS. AIRCRAFT MOVEMENT

If the main cause of slipperiness is identified to be the presence of rubber deposits then obviously the solution is to remove the rubber build-up.

Approved methods of removing rubber are:

1. High pressure water blast.
2. Mechanical grinding.
3. Impact hammering.

Runways that are slippery due to surface smoothness (low macrotexture) can be retextured by the use of impact hammering.

For further details on methods to restore runway surface conditions see (1,6,7,8).

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