AIRCRAFT BRAKING ACTION ON WET RUNWAYS

This appendix presents a brief, simplified description of some of the effects experienced by aircraft on wet runways.

Water on a runway reduces the area of contact between an aircraft tyre and the runway surface and, because the coefficient of friction between rubber and water is very low, the friction felt by the tyre on the runway is reduced. If the water between the tyre and the runway cannot flow away or be squeezed out, the aircraft will lose braking effectiveness. The rate at which the water can escape from beneath the tyre depends not only on the characteristics of the aircraft tyre but also on the nature of the runway surface. If the runway has a course texture offering many drainage channels or has an artificially applied texture such as grooves, scores or a brushed finish, it is said to have a high macrotexture. For effective contact with the runway, the tyre must also break through any residual thin film of water left after drainage and, in this respect, the sharpness of the texture of the asperities of the runway, or microtexture, is significant.

Dynamic hydroplaning

The squeezing action of the tyre generates water pressure that can lift portions of the tyre from the runway. If the water depth is sufficient the tyre may lift from the runway entirely and ride on a wedge of water. This condition is known as dynamic hydroplaning and is comparatively rare. The depth of water required to produce this condition depends among other things upon the tyre pressure, contact area, tyre tread pattern and depth, and the macrotexture of the runway surface.

Viscous hydroplaning

Viscosity resists the squeezing action of the tyre, tending to maintain a thin film of water that lubricates the contact area between the tyre and the runway surface and makes the runway slippery. Viscous hydroplaning is the most extreme manifestation of this slipperiness, when the tyre ceases to rotate. Viscous effects are the most common reason for the reduction of braking effectiveness on wet runways. They are most likely to be encountered on smooth runways ie, those with poor microtexture.

Reverted rubber hydroplaning

If a wheel skids along a runway, the heat generated in that part of the tyre in contact with the surface melts the rubber and causes a severe reduction of friction coefficient. Rubber reversion can occur only when a wheel is not rotating (braked or unbraked) for a significant period.

The friction felt by an aircraft tyre on a wet runway varies with speed. Dynamic hydroplaning can start only at high speeds but, once initiated, can continue to speeds below hydroplaning speed. Viscous effects are more marked at high speeds because of the lesser time of contact between the tyre and each element of the runway surface. Because of this variation of friction with speed, it is more difficult to measure the available friction of a wet runway than it is to measure that of a runway contaminated by ice or snow, when the friction coefficient is less dependent on speed.

Modern aircraft anti-skid systems are designed to modulate brake pressure according to the friction available between the tyre and the runway surface with the aim of maintaining the highest brake pressure that can be applied without locking the wheels. The performance of an anti-skid system deteriorates if the rate at which a wheel spins up after an incipient skid is reduced by hydrodynamic or viscous effects on a wet runway. If this occurs the mean brake pressure to the aircraft's wheels can be markedly reduced, particularly during the high speed portion of the landing roll, and braking effectiveness will consequently be lower. Braking effectiveness will also be reduced if the wheels encounter varying levels of friction on a wet runway because brake pressure will be released or reduced each time the wheels encounter lower friction.

Wet runway friction measurement

As a result of accidents when aircraft have overrun or left the side of wet runways, several programmes have been conducted by ICAO and individually by member states over many years to define the available friction of a wet runway and relate it directly to the brake effectiveness of aircraft.

During these programmes several different aircraft tyres, runway surfaces and ground friction measuring vehicles were used. It was found that different aircraft produced similar results on the same surfaces but no direct correlation was found between ground vehicle friction measurements and aircraft stopping performance. The present situation is summarised in the ICAO Airport Services Manual, Part 2, Chapter 3, which states:

> "3.1.1 . . . . Indication of the friction characteristics of a wet runway can be obtained by test devices; however, further experience is required to correlate the results obtained by such devices with aircraft stopping performance due to the many variables involved . . . .
>
> "3.1.3 Present technology does not permit direct and immediate correlation of runway surface friction measurements, taken with a test device, with aircraft stopping performance on wet runways. It has been found, however, that the wet runway friction characteristics of a surface remain relatively constant and deteriorate only slowly over long periods of time, depending on frequency of use. This finding is important for it eliminates the need to continually measure the friction characteristics of a wet runway. Also, although direct correlation between test devices and aircraft stopping performance does not exist, it is considered that test devices have the capability to distinguish between runway surfaces which have good or poor friction characteristics. It is, therefore, concluded that instead of reporting on an operational basis the friction characteristics of a wet runway, the runway be periodically tested to ensure that its friction characteristics are of an acceptable standard."

The relevant ICAO recommendations are contained in Annex 14 to the Convention on International Civil Aviation, which deals with aerodromes. This document recommends that friction tests should be made periodically to identify runways with low friction when wet and to identify runways in need of maintenance or surface treatment. These tests should be made with a uniform water depth using test equipment with a self-wetting device. Additional tests should be made periodically in conditions of natural rainfall if it is suspected that the braking characteristics of a runway may be affected by poor drainage. It also recommends that member states should define minimum friction levels below which runways should be classified as slippery when wet.

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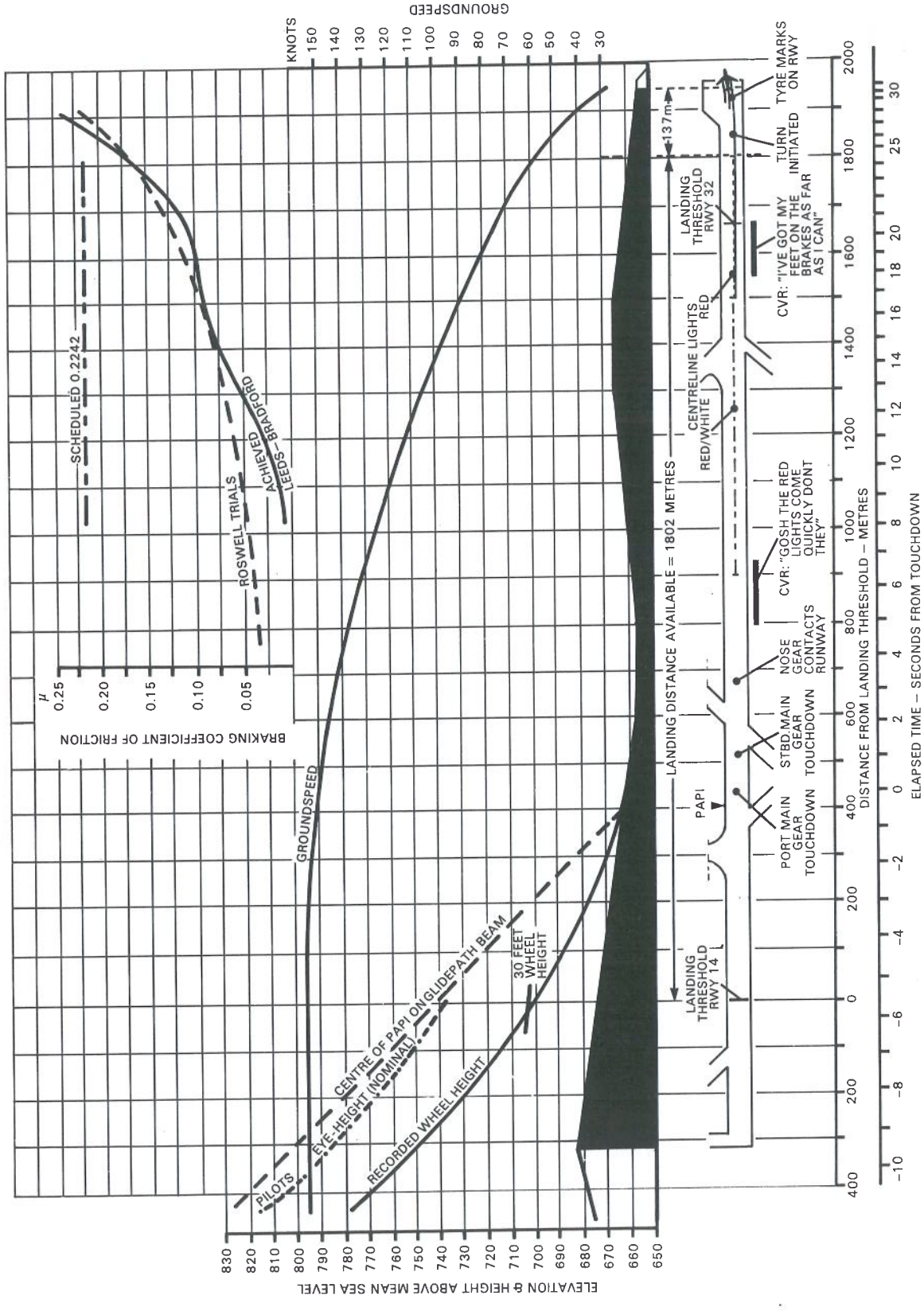
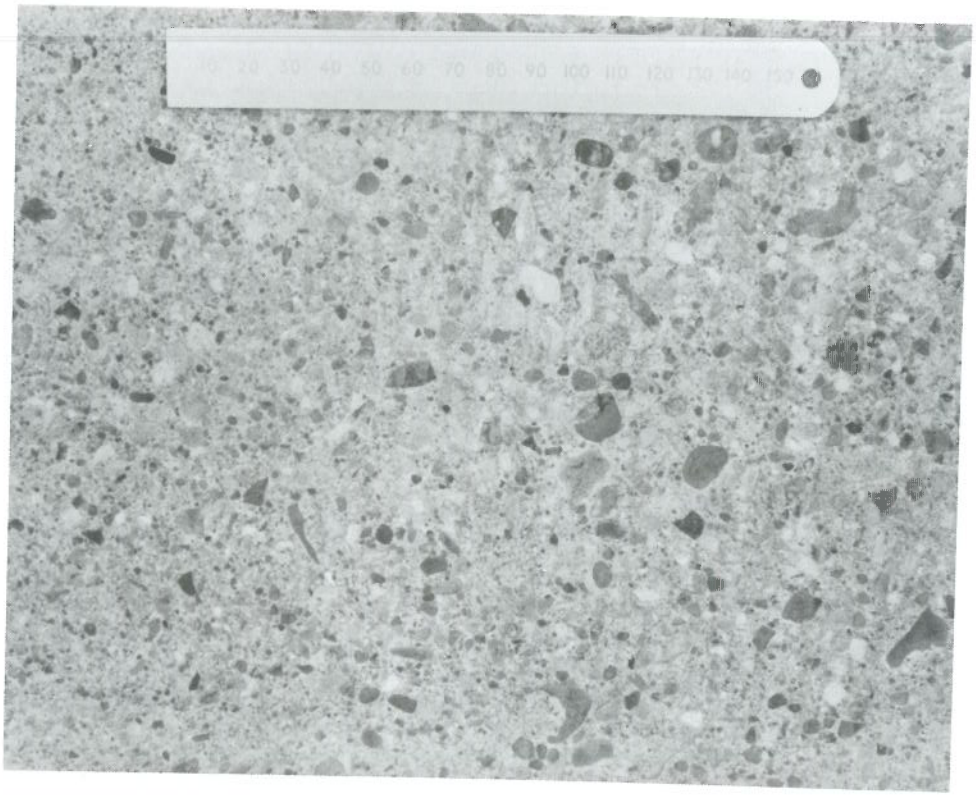
APPENDIX 2



ACCIDENT TO TRISTAR G–BBAI LEEDS– BRADFORD 27-5-85 FDR/CVR ANALYSIS

APPENDIX 3

PHOTOGRAPHS OF RUNWAY SURFACE TAKEN BY CRANFIELD INSTITUTE OF TECHNOLOGY

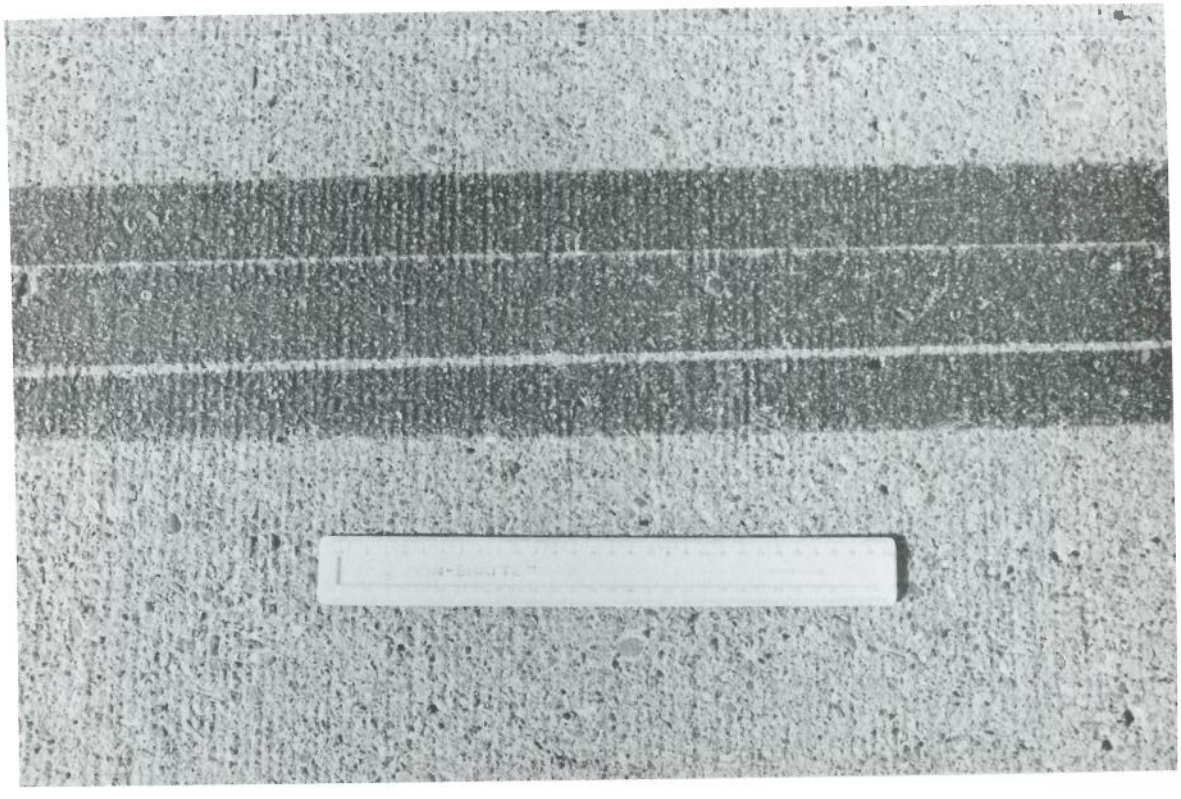


300 metres from 14 runway end

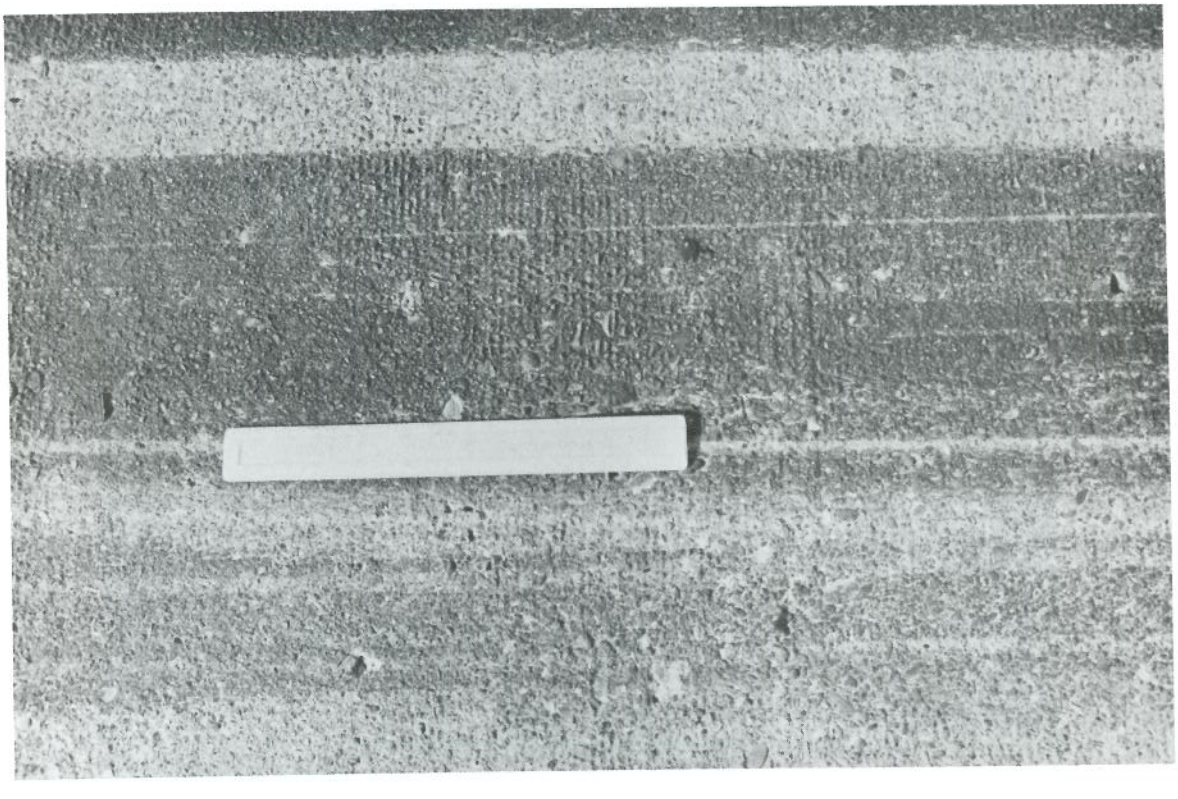
100 metres from 14 runway end

APPENDIX 4

PHOTOGRAPHS OF RUNWAY SURFACE TAKEN BY LEEDS–BRADFORD AIRPORT

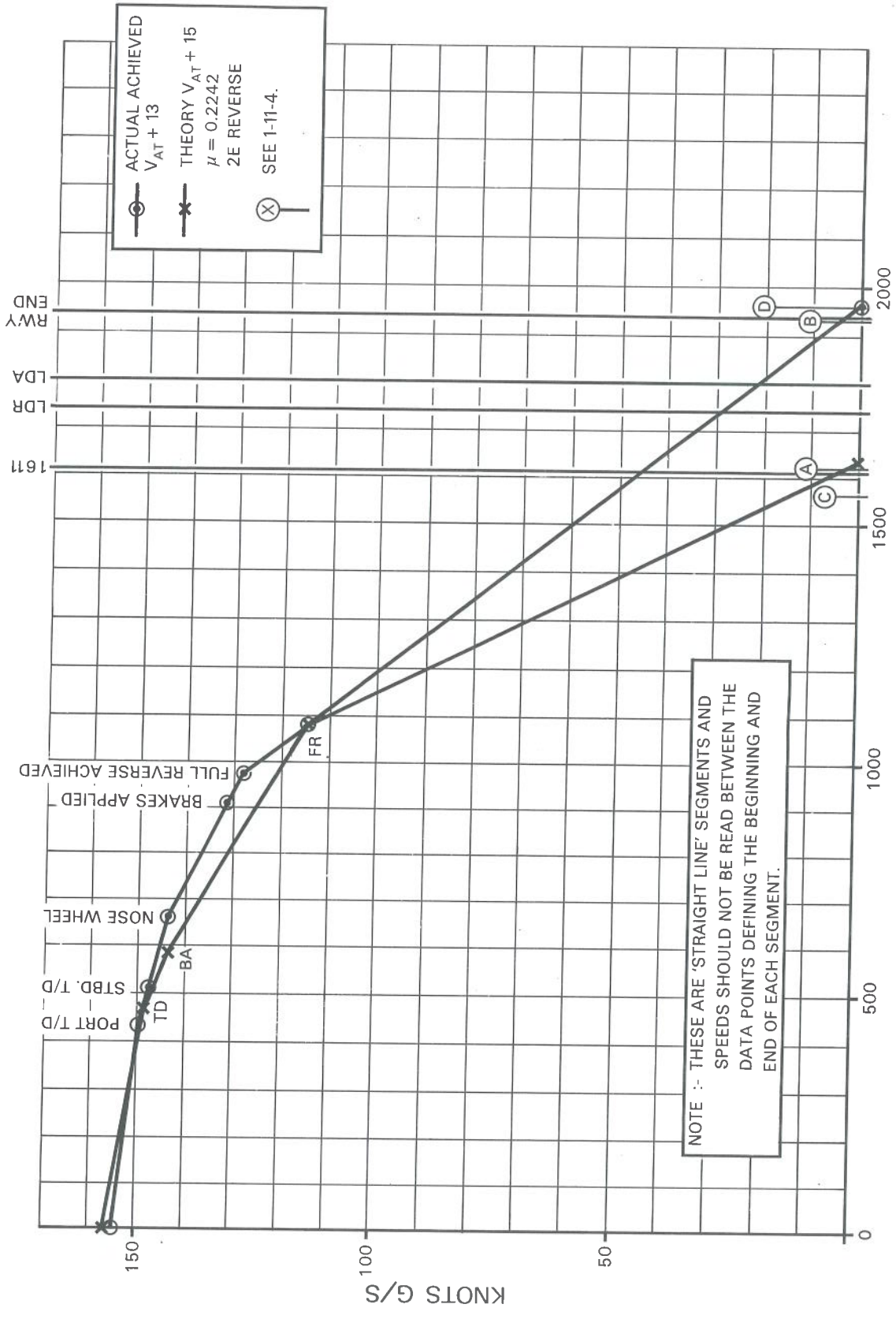


240 metres from 14 runway end



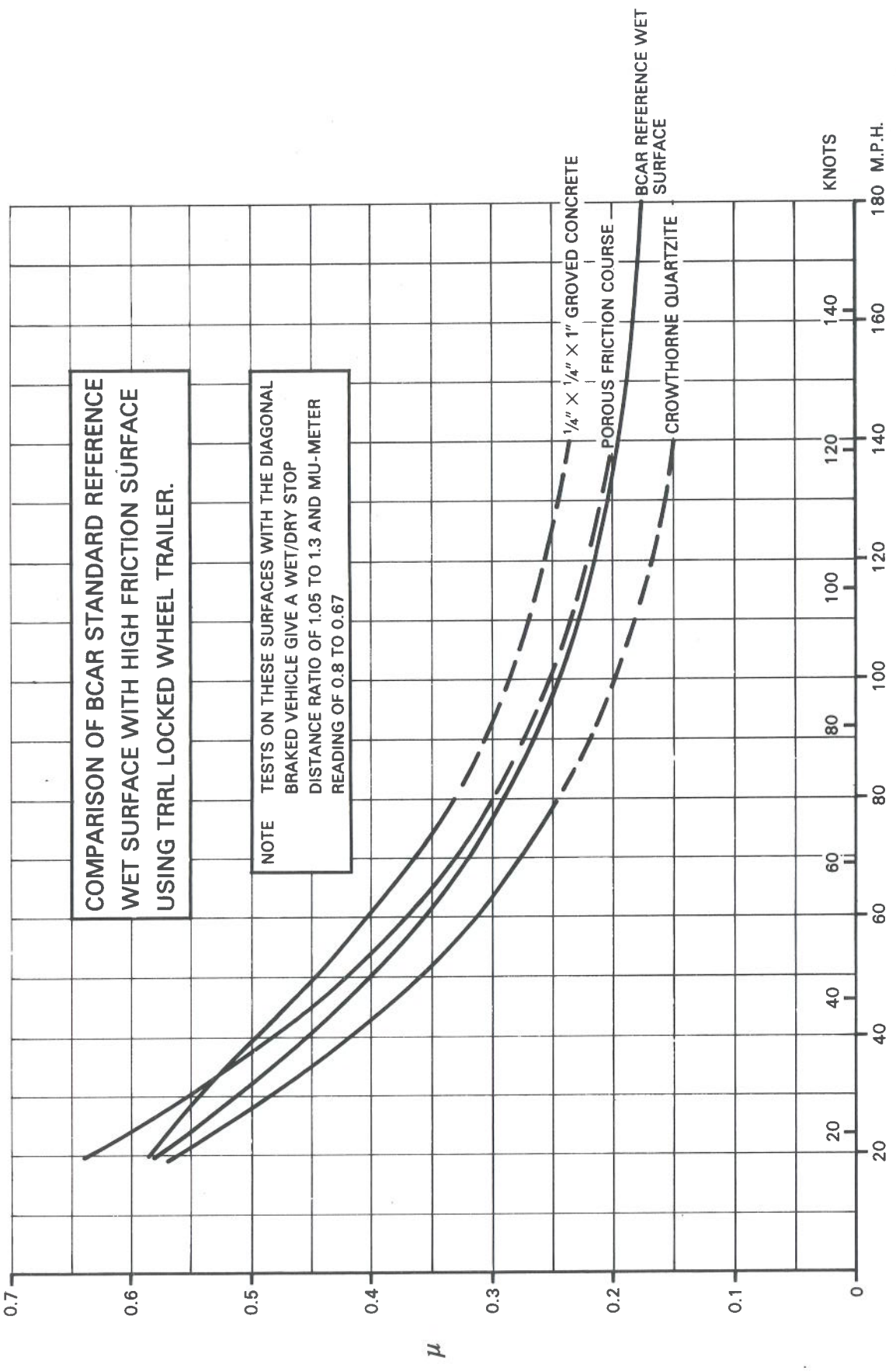
375 metres from 14 runway end

APPENDIX 5



COMPARISON OF SCHEDULED AND ACTUAL PERFORMANCE

APPENDIX 6


COMPARISON OF BCAR STANDARD REFERENCE WET SURFACE WITH HIGH FRICTION SURFACE USING TRRL LOCKED WHEEL TRAILER.
NOTE TESTS ON THESE SURFACES WITH THE DIAGONAL BRAKED VEHICLE GIVE A WET/DRY STOP DISTANCE RATIO OF 1.05 TO 1.3 AND MU-METER READING OF 0.8 TO 0.67
BCAR REFERENCE WET SURFACE
¼" × ¼" × 1" GROVED CONCRETE
POROUS FRICTION COURSE
CROWTHORNE QUARTZITE
μ
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
KNOTS
20
40
60
80
100
120
140
M.P.H.
20
40
60
80
100
120
140
160
180