

Accumulation of water on runway

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ACCUMULATION OF WATER ON RUNWAYS

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ACCUMULATION OF WATER ON RUNWAYS

1. NOTATION AND DEFINITIONS

1.1 Notation

Symbol	Meaning	Dimensions
d_C	accumulated water depth	L
d_E	effective depth of surface fill (see Table 4.1) [†]	L
d_{TEX}	average surface texture depth	L
g	acceleration due to gravity	LT ⁻²
H	pressure head due to gravity	ML ⁻¹ T ⁻²
H_{REF}	reference pressure head due to gravity	ML ⁻¹ T ⁻²
I	time rate of rainfall	LT ⁻¹
l	drainage length from watershed	L
l_F	reference drainage length from watershed	L
n	number of observations in correlation	—
$Re_{(d_C + d_{TEX})}$	Reynolds number on accumulated water depth	—
Re_l	Reynolds number on drainage length	—
S	surface slope (in radians)	—
$t_{5,5}$	Student's t distribution value for five degrees of freedom and 95 per cent confidence interval (two-tail distribution, $\alpha = 0.05$)	—
u_W	velocity of propagation of water waves	LT ⁻¹
α	significance level	—
α_0	dimensional (empirical) constant (see Table 4.1)	L ⁻¹
β	empirical parameter used to determine accumulated water depth	—
β_0	dimensionless (empirical) constant used to determine β (see Table 4.1)	—
γ	empirical parameter used to account for non-linearity	—

γ_0	dimensionless (empirical) constant used to determine γ (see Table 4.1)	—
Δ	deviation of measured depth from correlation	L
ν	kinematic viscosity of water	L^2T^{-1}
ρ_C	density of water	ML^{-3}
ϕ_1	dimensionless length parameter	—
ϕ_2	dimensionless speed parameter	—
ϕ_E	effective porosity of surface	—
Φ	dimensionless parameter	—
$E[\]$	expected value of quantity in []	—
$M[\]$	measured value of quantity in []	—
$O[\]$	observed value of quantity in []	—
$\Pi[\]$	precision of quantity in []	—

† See Reference 5 for an independent derivation for effective fill-size.

1.2 Definition

Watershed an area or ridge of land that separates waters flowing to different destinations. The crown of a conventional runway.

2. INTRODUCTION

2.1 General

Accumulations of water on airfield runways affect aircraft operations in three ways.

- (1) In damp conditions, although there is no measurable depth of water, there is a loss of adhesion between tyre and surface that follows from a masking of the sharpness of the micro-texture. In terms of braking action, on a runway constructed with adequate sharpness, this loss of adhesion can be trivial, especially when the surface is well-maintained.
- (2) As rainfall rate rises and becomes significant, accumulations of water arise that inhibit the drainage effect due to macro-texture. Braking action further diminishes and planing ultimately occurs so that braking action and (non-aerodynamic) directional control is lost.
- (3) Furthermore, accumulations in troughs and tyre-tracks may be such that impingement of spray on to an airframe, together with ingestion of spray into intakes, may result in unacceptable loss of take-off performance.

This Data Item is an analysis of the available, relevant experimental data for accumulation on *ungrooved* surfaces[†]. An algebraic, empirical model is developed from laboratory experiments that is confirmed to be applicable to an operational surface. Statistically, the modelling is shown to be adequately precise; experimental data are described to within one half millimetre.

2.2 Rainfall

There are many classifications for rainfall rates; the simplest of which is given in Table 2.1. Those are likely to be applicable to the weather conditions found in the temperate regions of Western Europe and the United States of America. Experiments used in formulating the modelling in this Data Item were conducted in conditions covering all classifications in Table 2.1 with the exception of “Light” and “Slight”. Intensities in that category give rise to accumulations that are too small to be measured within the precision of the methods used in the experiments considered.

TABLE 2.1 Classification of rainfall

Classification	Time Rate of Rainfall (I) (mm/hr)	Source of classification
Light	$I \leq 2.5$	Reference 7
Slight	$I \leq 2$	Reference 4
Moderate	$2.5 < I \leq 7.6$	Reference 7
	$2 < I \leq 10$	Reference 4
Heavy	$I > 7.6$	Reference 7
	$10 < I \leq 50$	Reference 4
Violent	$I > 50$	Reference 7

3. SURFACES

Reference 1 is a seminal laboratory study of the extent to which water may have been expected to accumulate on surfaces that were likely to be found on highways in Texas in the mid-20th century. Nine surfaces were constructed; six of which are nearly representative of those which are used on current airfield runways. In the course of the experiments various values of rainfall rate and surface slope were used. Measurements of water depth were taken at four distances from the watershed.

Values of water depth in the experiments reported in Reference 1 are defined from the top of the asperities in the surfaces. In the studies conducted at ESDU, it is assumed that, for each surface, there exists a datum to which all water depths may be adjusted. This datum is assumed to be the top of the impervious layer at the base of the (permeable) texture.

In addition to the laboratory experiments reported in Reference 1, data collected from another laboratory surface (Reference 2), and an operational runway (Reference 3) have been included in the correlation described. Some details are set down in Table 3.1.

[†] Grooved surfaces will be considered in a further Data Item.