



Effect of planform geometry on low speed pitch-break characteristics of swept wings

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EFFECT OF PLANFORM GEOMETRY ON LOW SPEED PITCH-BREAK
CHARACTERISTICS OF SWEEP WINGS

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EFFECT OF PLANFORM GEOMETRY ON LOW SPEED PITCH-BREAK CHARACTERISTICS OF SWEEPED WINGS

1. NOTATION AND UNITS

		SI	British
A	aspect ratio, b^2/S		
b	span of gross wing, $2s$	m	ft
C_L	lift coefficient		
C_{Lmax}	maximum lift coefficient		
C_m	pitching moment coefficient (positive nose-up) about axis through quarter-chord point of wing aerodynamic mean chord (see Sketch 1.1) representing aircraft centre of gravity location, based on S and $\bar{c}$		
c	local chord parallel to wing centre-line	m	ft
c_0	centre-line chord of equivalent straight-tapered gross wing (see Sketches 1.1 and 1.2)	m	ft
c_1	wing chord at crank (see Sketch 1.2)	m	ft
c_r	root chord of true wing planform at wing-body junction (see Sketch 1.2)	m	ft
c_{re}	root chord of equivalent straight-tapered wing (see Sketch 1.2)	m	ft
c_t	tip chord, see Sketches 1.1 and 1.2	m	ft
$\bar{c}$	standard (or geometric) mean chord of gross wing	m	ft
$\bar{\bar{c}}$	aerodynamic mean chord of gross wing, see Sketch 1.1	m	ft
D	body diameter (or width), $2s_0$	m	ft
M	freestream Mach number		
$R_{\bar{c}}$	Reynolds number based on aerodynamic mean chord		
S	gross wing area, $b\bar{c}$	m ²	ft ²
S_e	area of exposed wing	m ²	ft ²
s	semi-span of gross wing (see Sketches 1.1 and 1.2)	m	ft
s_0	spanwise distance to root chord (see Sketch 1.2)	m	ft

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2. INTRODUCTION

A form of disruption to longitudinal stability, known as 'pitch-up', is associated with swept wings. A wing has longitudinal static stability if the aerodynamic forces and moments produced by an incremental or decremental change in angle of attack tend to return the wing to its original angle of attack.

For stability, with the pitching moment coefficient defined about the centre of gravity location and positive nose-up, the derivative $\partial C_m / \partial C_L$ must always be negative, and it should ideally be constant. The illustrative pitching moment curve in Sketch 2.1a shows stability up to point 'P' after which the slope of the curve becomes positive. An incremental change in angle of attack after point 'P' will result in a nose-up change in attitude (pitch-up). If the slope steepens, the nose-up change in attitude rapidly increases until the maximum lift coefficient, C_{Lmax} , is approached. Conversely, if the slope of the pitching-moment curve beyond 'P' becomes increasingly negative (Sketch 2.1b), the nose-down change in attitude (pitch-down) caused by an incremental change in angle of attack becomes increasingly rapid, and there is an ever greater risk of an excessive restoring moment leading to dynamic instability. Severe pitch-up or pitch-down beyond point 'P' should be avoided.



Sketch 2.1 Pitching-moment curves

This Item provides a means of predicting the type of pitch-break (pitch-up or pitch-down) likely to be encountered for a given wing planform shape at low speeds. The type of pitch-break occurring at high speeds is largely influenced by compressibility effects and is not dealt with in this Item. Low speed pitch-break characteristics may be improved after the selection of the planform geometry by the use of wing twist, possibly in combination with palliatives such as fences and vortex generators.

The method has been developed for wings alone and wing-body configurations. The wing-body data studied relate to configurations with bodies of approximately circular cross section where the body width is small in comparison to the wing span. For those configurations the body has no discernible effect on the type of pitch-break.

Section 3 describes the method for predicting the type of pitch-break in terms of aspect ratio and sweep. Many experimental data covering a wide range of planform geometries were studied to form the basis of the method. The database covers data for 392 wings and 30 wing-body combinations and in all cases the wind-tunnel models were aerodynamically clean.

Section 4 discusses the effect of planform geometry on flow fields and pitch characteristics.

After the accuracy and applicability have been discussed in Section 5, and the Derivations listed in Section 6, there are two worked examples in Section 7, showing the application of the method.