STABILITY DERIVATIVE L_p. EFFECT OF FUSELAGE INTERFERENCE ON ROLLING MOMENT DUE TO ROLLING AT SUPERSONIC SPEEDS

1. NOTATION AND UNITS

The derivative notation used is that proposed in ARC R&M 3562 (Hopkin, 1970) and described in Item No. 86021. Coefficients and aeronormalised derivatives are evaluated in aerodynamic body axes with origin at the aircraft centre of gravity and with the wing span as the characteristic length. The derivative L_p is often written as C_{lp} in other systems of notation, but attention must be paid to the reference dimensions used. In particular, in forming C_{lp} differentiation of C_l may be carried out with respect to $pb/2V$ not pb/V as implied in the Hopkin system. It is also to be noted that a constant datum value of V is employed by Hopkin.

		SI	*British*
A	aspect ratio, b^2/S		
b	wing span	m	ft
C_l	rolling moment coefficient, $\mathscr{L}/(\frac{1}{2}\rho V^2 S b)$		
d	body diameter	m	ft
$\mathscr{L}$	rolling moment	N m	lbf ft
L_p	rolling moment derivative due to rolling, $(\partial\mathscr{L}/\partial p)/\frac{1}{2}\rho V S b^2$		
$L_{p(d/b)\,=\,0}$	rolling moment derivative due to rolling of wing alone		
M	free-stream Mach number		
p	angular velocity in roll	radian/s	radian/s
S	gross wing area (shown shaded in sketches in Figures 1 and 2)	m^2	ft^2
V	airspeed	m/s	ft/s
β	Mach number parameter, $(M^2-1)^{\frac{1}{2}}$		
ρ	air density	kg/m^3	$slug/ft^3$

Issued April 1957
With Amendment A, October 1982 - 3 pages

ESDU Copyright material. For current status contact ESDU.

Documents
Document Sharing Hub

Copyright Engineering Sciences Data Unit
Provided by IHS Markit under license with ESDU
No reproduction or networking permitted without license from IHS
Full document details: ESDU AERO A.S.06.03.02 A 1982

Licensee=/, User=,
Not for Resale,

2. NOTES

The Figures give values of $L_p/L_{p(d/b)=0}$ as functions of d/b for various values of the parameter βA; Figure 1 gives values for delta wings, Figure 2 for rectangular wings.

The curves were obtained from Derivations 1 and 2. Derivation 1 gives curves which are based on slender-wing theory. Derivation 2 gives a linear-theory method of which the essential feature is the representation of the effect of the body on the wing by an arbitrarily chosen source distribution. For the rectangular wing, at finite values of βA the restriction exists that the theory is valid only if the Mach line from the leading edge of the wing-body junction does not cross the wing tip. This may be expressed mathematically as

$$\frac{d}{b} \leq 1 - \frac{2}{\beta A}. \tag{2.1}$$

Experimental evidence indicates that the curves are accurate to within ± 7 per cent, and it is suggested that for planforms other than delta and rectangular the same general trend of variation with d/b is to be expected, particularly over the range of practical values of d/b.

There is no available evidence as to the effect of incidence on fuselage interference on L_p.

3. DERIVATION

The Derivation lists selected sources that have assisted in the preparation of this Item.

1.	HEASLET, M.A. LOMAX, H.	Damping in roll calculations for slender swept-back wings and slender wing-body combinations. NACA tech. Note 1950, 1949.
2.	TUCKER, W.A. PILAND, R.O.	Estimation of the damping in roll of supersonic leading edge wing-body combinations. NACA tech. Note 2151, 1950.
3.	–	Unpublished rocket-powered model tests.

4. EXAMPLE

Find the rolling moment derivative due to rolling at a Mach number of 2 for a delta wing-body combination for which $A = 4$, $d/b = 0.3$, given that for the wing alone $L_{p(d/b=0)} = -0.100$.

$$\beta A = (2^2 - 1)^{\frac{1}{2}} \times 4 = 6.93.$$

From Figure 1, $L_p/L_{p(d/b=0)} = 0.94$,

so that
$$\begin{aligned} L_p &= -0.100 \times 0.94 \\ &= -0.094. \end{aligned}$$

ESDU Copyright material. For current status contact ESDU.
Documents Document Sharing Hub
Copyright Engineering Sciences Data Unit
Provided by IHS Markit under license with ESDU
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ESDU AERO A.S.06.03.02 A 1982