

AERODYNAMIC CENTRE IN TWO-DIMENSIONAL FLOW

1. NOTATION AND UNITS

		<i>SI</i>	<i>British</i>
$(a_1)_0$	aerofoil lift-curve slope in incompressible flow	rad ⁻¹	rad ⁻¹
$(a_1)_{0T}$	aerofoil lift-curve slope in incompressible inviscid flow	rad ⁻¹	rad ⁻¹
c	aerofoil chord	m	ft
h_0	chordwise position of aerodynamic centre in incompressible flow	m	ft
h_{0T}	chordwise position of aerodynamic centre in incompressible inviscid flow	m	ft
t	aerofoil maximum thickness	m	ft
x_t	chordwise position of maximum thickness	m	ft
τ	aerofoil trailing-edge angle	deg	deg
ϕ_1	trailing-edge angle factor	deg ⁻¹	deg ⁻¹
ϕ_2	thickness/chord ratio factor		

2. NOTES

The ratio $(1 - h_0/h_{0T})/[1 - (a_1)_0/(a_1)_{0T}]$ is plotted in Figure 1 against the trailing-edge angle, τ .

The theoretical aerodynamic centre position in incompressible inviscid flow may be obtained from a transformation of the aerofoil to a circle. If the trailing-edge angle and thickness/chord ratio are considered to first order only, then

$$\frac{h_{0T}}{c} = 0.25 \left(1 + \tau \phi_1 + \frac{t}{c} \phi_2 \right), \quad (2.1)$$

in which ϕ_1 and ϕ_2 are functions of the chordwise position of maximum thickness and are given by Figure 2. When the aerofoil trailing-edge angle, τ , is less than $100t/c$, a closer approximation to exact theory is given by

$$\frac{h_{0T}}{c} = \left[0.25 + 0.28 \left(\frac{t}{c} \right)^2 \right] \left(1 + \tau \phi_1 + \frac{t}{c} \phi_2 \right). \quad (2.2)$$

The ratio of lift-curve slopes, $(a_1)_0/(a_1)_{0T}$, for a given transition position and Reynolds number should be obtained from Item No. Aero W.01.01.05.

Although Item No. 72024 gives more accurate estimates for h_{0T} , these values should not be used in conjunction with this Item. This is because data for h_{0T} obtained via Equations (2.1) and (2.2) were used in deriving Figure 1.

The order of accuracy of this Item is within the limits of experimental error and of errors in measuring the slopes of the lift and pitching moment curves from which the aerodynamic centre position is calculated, *i.e.* within $\pm 0.005c$.

The data in Figure 1 were derived from tests in two-dimensional flow (Derivations 1 and 2[†]) and should not, therefore, be applied to wings of finite aspect ratio.

3. DERIVATION

1. THOMAS, H.H.B.M. Correlation of the position of the aerodynamic centre of an aerofoil with the rate of change of the lift coefficient with incidence.
RAE tech. Note Aero. 2029 (ARC 12965), 1949.
2. BRYANT, L.W. Two-dimensional control characteristics.
HALLIDAY, A.S. ARC R&M 2730 (ARC 13039, 13065), 1955.
BATSON, A.S.

4. EXAMPLE

Find the position of the aerodynamic centre in incompressible flow of an aerofoil having the following geometrical data:

$$t/c = 0.12, \quad x_t/c = 0.40, \quad \tau = 11 \text{ degrees.}$$

Reynolds number = 2×10^7 and transition occurs at $0.5c$.

From Item No. Aero W.01.01.05, for the given Reynolds number and transition position,

$$(a_1)_0/(a_1)_{0T} = 0.905.$$

From Figure 1, with $\tau = 11$ degrees,

$$\frac{1 - h_0/h_{0T}}{1 - (a_1)_0/(a_1)_{0T}} = 0.330.$$

Thus, $h_0/h_{0T} = 0.969$.

[†] The data in Derivation 2 led to a modification of the original empirical correlation given in Derivation 1.