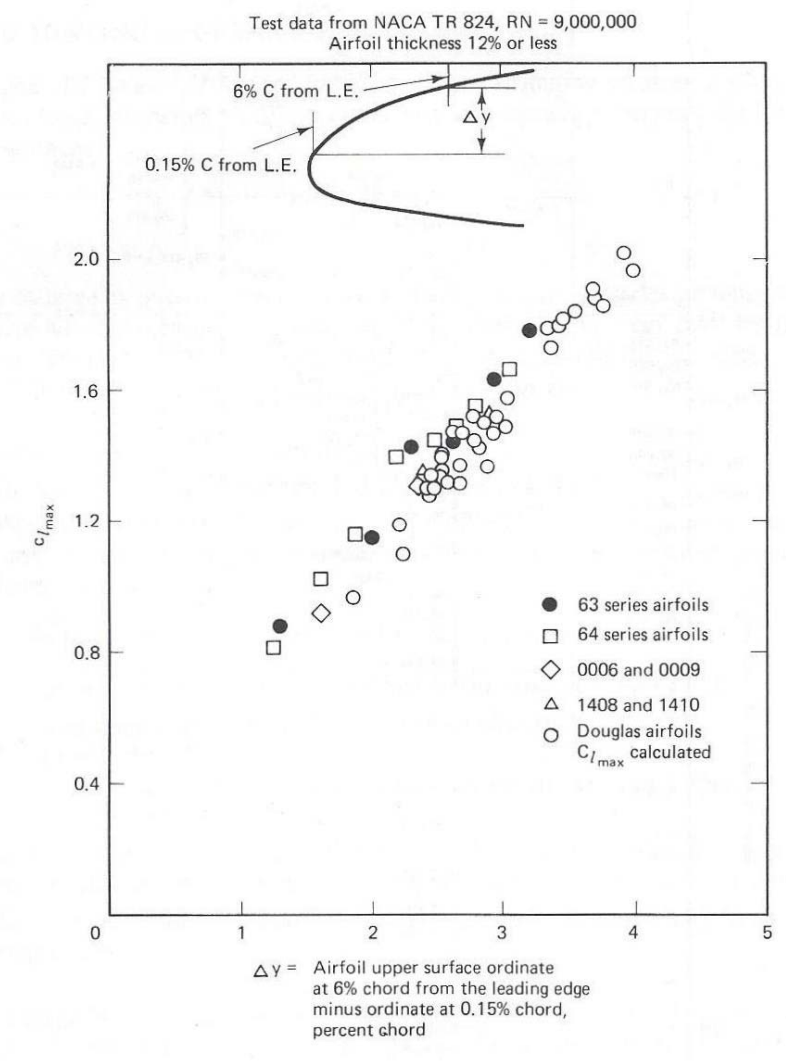
12.4.5 Maximum Lift (Clean)

For high aspect ratio wings with moderate sweep and large airfoil leading edge radius, Raymer offers a simple equation for estimating $C_{L_{max}}$. This is given as

$$C_{L_{max}} = 0.9\, C_{l_{max}} \cos \Lambda_{0.25c} \tag{12.15}$$

However, he doesn't offer a procedure for the estimation of the section lift coefficient, $C_{l_{max}}$. For wings with airfoil sections that are a function of span (i.e., different airfoil sections inboard and outboard), the section should be used where the stall first occurs, which is usually designed to be inboard.

For airfoils with thickness of 12% or less, Shevell (Ref. 12.4.5.1), shows a relationship between $C_{l_{max}}$ and Δy, the non-dimensional airfoil upper surface sharpness parameter.



Source: Shevell

Fig 12.4.5.1 Section $C_{l_{max}}$ as Function of Upper Surface Sharpness Parameter

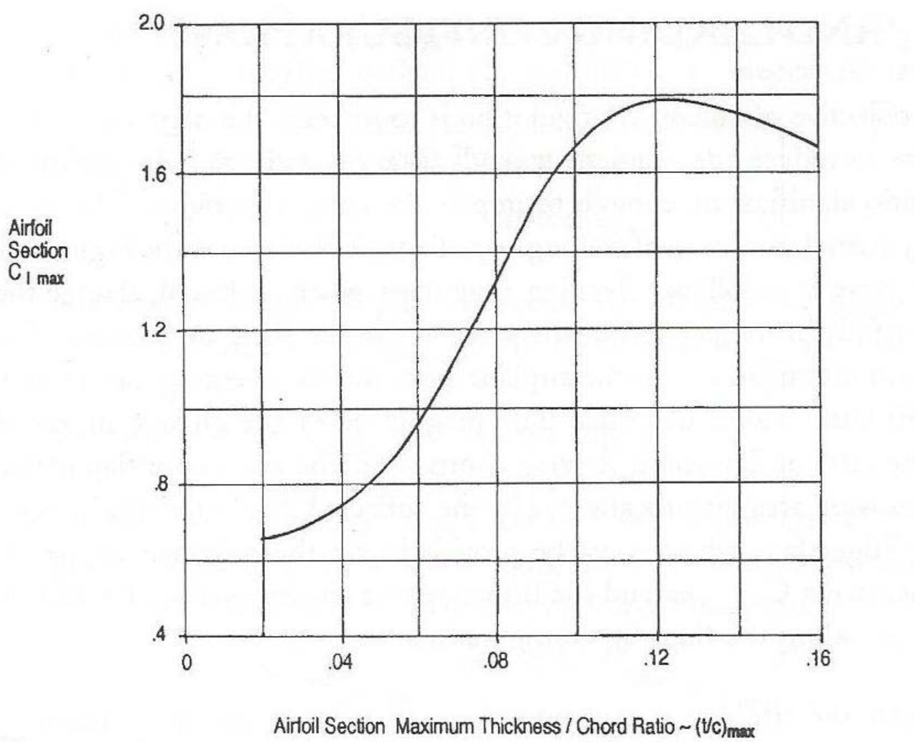
For any airfoil for which the section geometry is known, then the value of Δy can be calculated directly. For the supercritical airfoil SC(2)-0610 illustrated in the Annotation to Section 12.1, the sharpness parameter is calculated in Table 12.4.5.1 as 2.44% yielding a value of $C_{l_{max}}$ of about 1.35 from Fig. 12.4.5.1. The coordinates of other supercritical airfoil sections may be found in Ref. 12.4.5.2.

$(x/c)_{upper}$	Δy/c
0.060	0.0309
0.015 (from surface plot)	0.0065
Sharpness parameter	0.0244

Table 12.4.5.1 Example of Sharpness Parameter Calculation for SC(2)-0610

Raymer Table 12.1 shows values of Δy for some typical airfoil sections as a function of t/c. For example, for a NACA 4 or 5 digit airfoil with t/c = 10%, then Δy = 26 x 0.1 = 2.6%, yielding a value of $C_{l_{max}}$ of about 1.4.

Shevell points out that for airfoils greater than about 12% thickness, separation at the stall usually occurs at the point of maximum thickness, rather than close to the leading edge. For this case, Fig. 12.4.5.2 (from Schaufele) may be used. This figure may also be used for an approximate value of $C_{l_{max}}$ if the wing section is not otherwise known.



Source: Schaufele

Fig. 12.4.5.2 $C_{l_{max}}$ as a Function of $(t/c)_{max}$

References

12.4.5.1 Shevell, R.S., "Fundamentals of Flight", Prentice-Hall, 1989.
12.4.5.2 Harris, C.D., "NASA Supercritical Airfoils", NASA TP-2969, March 1990.
12.4.5.3 Schaufele, R.D., "The Elements of Aircraft Preliminary Design", Aries Publications, 2007.