Optimum Aspect Ratio the Performance For a Sailplane.

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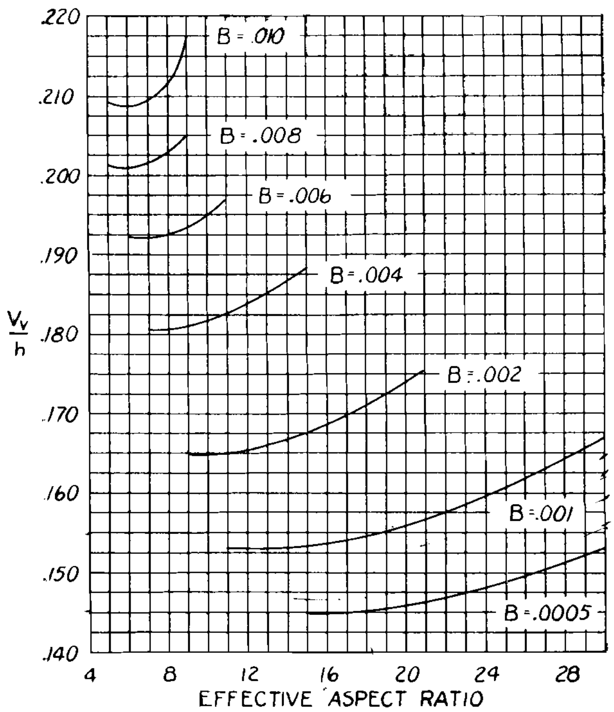

Fig. 3. Lowest Sinking Speed for Given Effective Aspect Ratio and Value of B and h.

$$C_D = \frac{X + y\,(C_L - C_{LO})^2 + B\Lambda + C_L^2/\Lambda}{\pi}$$

Aspect Ratio for Flattest Gliding Angle.

The inverse of the gliding angle can be written to the usual approximation as equal to C_D/C_L but

$$C_D/C_L = \frac{X + yC_L^2 - 2yC_LC_{LO} + yC_{LO}^2 + B\Lambda + C_L^2/\Lambda}{\pi\,C_L} \quad \text{eq. (1)}$$

which contains only two variables, C_L and Λ

By minimising eq. (1) the effective aspect ratio, Λ_G, for flattest gliding angle is found to be $\Lambda_G = C_{LX}/\sqrt{B}$.

Aspect Ratio for Lowest Sinking Speed.

To the usual approximation the sinking speed, V_v, in ft./sec. is $V_v = VC_D/C_L$ where V is the foreward speed in ft./sec. but $V = \sqrt{\frac{2W}{\rho S C_L}} = \frac{h\Lambda^{1/2}}{C_L^{1/2}}$ or

$V_v = hC_D\Lambda^{1/2}/C_L^{3/2}$

$$V_v = \frac{h}{\pi}\left[\frac{X + yC_L^2 - 2yC_LC_{LO} + yC_{LO}^2 + B\Lambda + C_L^2/\Lambda}{C_L^{3/2}\,\Lambda^{-1/2}}\right] \quad \text{eq. (2)}$$

Minimising eq. (2) gives for the aspect ratio, for minimum sinking speed.

$$\Lambda_S = \frac{y\,C_{LX}}{3\,B}\left[\sqrt{(C_{LX} - C_{LO})^2 + \frac{3B}{y^2}} - (C_{LX} - C_{LO})\right]$$

Flattest Gliding Angle, and Forward Speed for Flattest Gliding Angle, for An Arbitrary Aspect Ratio.

Equating the partial derivitive, with respect to C_L, of eq. (1) to zero and solving for C_L gives the lift coefficient for flattest gliding angle, which is $C_{Lq} = \sqrt{\frac{\Lambda(X + yC_{LO}^2 + B\Lambda)}{y\Lambda + 1}}$ substituting this value of C_L back in eq. (1) gives the Flattest Gliding Angle for the given design and aspect ratio.

The forward speed in M. P H. at best gliding angle is

$V' = 1.47\,h\Lambda^{1/2}/C_{Lq}^{1/2}$

Lowest Sinking Speed for An Arbitrary Aspect Ratio.

In a similar manner to that for Flattest Gliding Angle, the lift coefficient for Lowest Sinking Speed, C_{LV}, is found to be

$$C_{LV} = \frac{\sqrt{y^2C_{LO}^2 + 3\left(\frac{y\Lambda + 1}{\Lambda}\right)\left(X + yC_{LO}^2 + B\Lambda\right)} - yC_{LO}}{\left(\frac{y\Lambda + 1}{\Lambda}\right)}$$

substituting this value of C_L back in eq. (2) gives the lowest sinking speed for the given design and aspect ratio.

DISCUSSION:

The curves were calculated for N. A. C. A. 63017 profile. Although the curves are only correct for this section they should be approximately correct, though probably optimistic, for any good glider airfoil.

Figure (1) gives the aspect ratios for flattest gliding angle and lowest sinking speed for various values of B.

Figure (2) gives the flattest gliding angles, and Figure (3) gives the lowest sinking speeds for arbitrary aspect ratios in the useful range for the various values of B and h.

Figure (4) gives the best cruising speed, in M.P.H., for arbitrary aspect ratios in the useful range and the various values of the weight parameter h. and the drag parameter B.

The fuselage parasite drag coefficient, C_{Dp} based on frontal area, will vary from about .06 for a well streamlined symmetrical fuselage to about .2 for the average secondary fuselage.

Example:

A cantilever sailplane is to be designed for cross-country work, with a 55 ft. span, elliptical planform, N.A.C.A. 63015 section at the tip, and 63018 at the center, the flying weight is estimated at 600 lbs., the fuselage parasite drag coefficient, C_{Dp}, is estimated to be equal to .1, and it is estimated that it will need about 25 sq. ft. of tail surface. The fuselage is to be elliptical in cross section about 4 ft. deep and 2 ft. wide. The profile drag coefficient of the tail section to be used is $C_{DO} = .01$

From the profile drag polar for the wing section it is seen that $C_{DOO} = .01$, $C_{LO} = .4$ and $C_{LX} = 1.05$.

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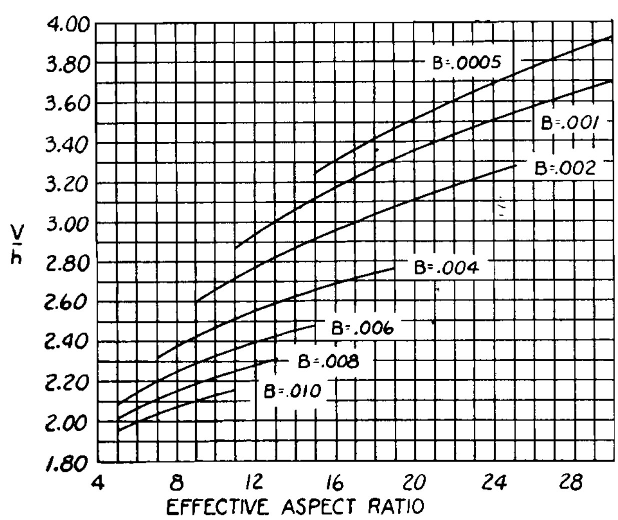

Fig. 4. Best Cruising Speed, V, in Miles per Hour, for Given Effective Aspect Ratio and Value of B and h.