The Selection of the
and a Direct Method of Calculating

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SUMMARY:

This article presents an analytical method for selecting the optimum aspect ratio for flattest gliding angle or lowest sinking speed for any given effective span, weight, wing section, and parasite drag of fuselage and tail. It also presents a direct method of calculating and a set of curves for quickly estimating the flattest gliding angle, lowest sinking speed, and forward speed for flattest gliding angle for any given effective span, aspect ratio, weight, wing section, and parasite drag of fuselage and tail.

INTRODUCTION:

The sailplane wing span which gives the ultimate in performance is almost always greater than is practical from the standpoint of maneuverability, ease of handling on the ground, and cost. Therefore, the span is usually determined by what the designer considers a good compromise. Once the span is fixed for any given design there is a certain aspect ratio which will result in the lowest possible sinking speed and some higher aspect ratio which will give the flattest possible gliding angle for that particular design. Obviously the aspect ratio to select for the given design should be between these limits. The method here given eliminates the necessity of running a complete performance analysis for each of a series of aspect ratios in order to find these limits.

Of foremost interest in evaluating the performance of a sailplane are: the flattest gliding angle, the lowest sinking speed, and the best cruising speed or the forward speed for flattest gliding angle. The direct method of finding these given in this article can save the designer considerable labor where it is desired to determine the effect of variations in the design upon the ultimate performance.

THEORY:

All equations are derived on the assumption that the induced drag of the tail is zero. That is, that the sailplane

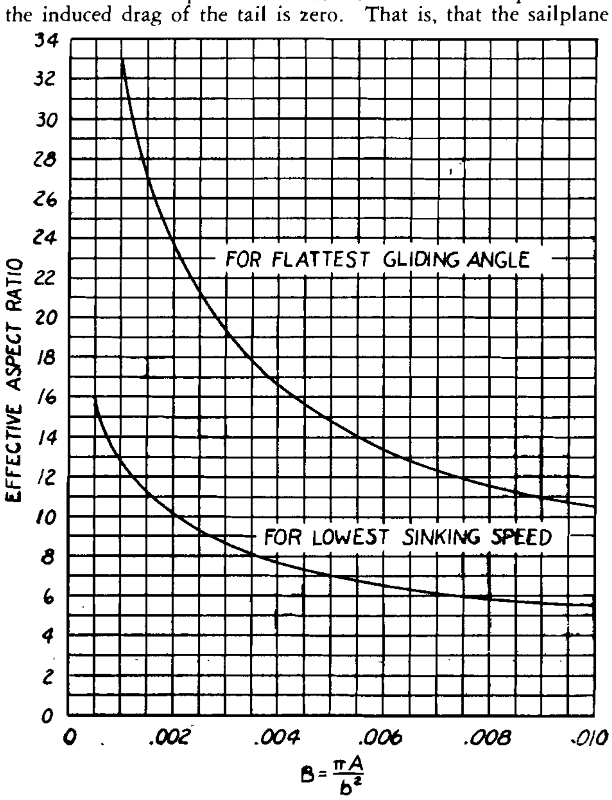

Fig. 1. Aspect Ratios for Flattest Gliding Angle and Lowest Sinking Speed. For N.A.C.A. 630 Series Wing.

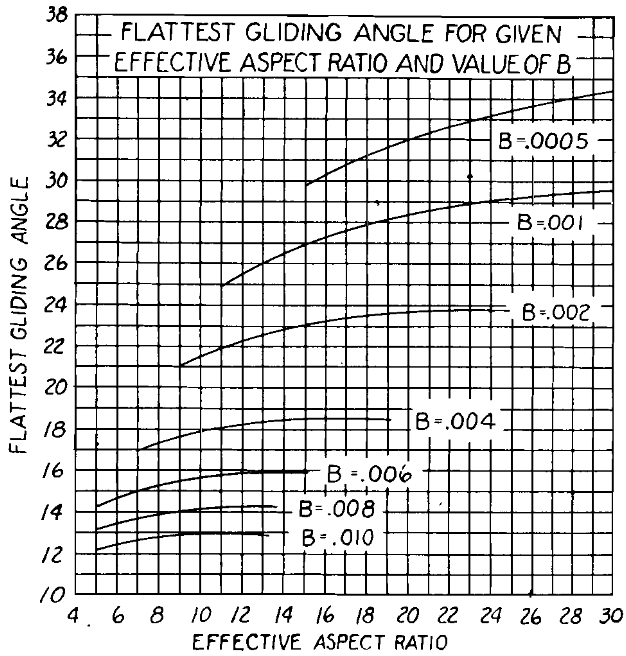

Fig. 2.

is balanced for zero tail load for the condition in question. It is also assumed that the weight is a function of the span only.

The profile drag coefficient, C_{DO}, of a wing section can be written with a sufficient degree of accuracy over the pertinent range of lift coefficients as $C_{DO} = C_{DOO} + a(C_L - C_{LO})^2$ where

C_{DOO} is the minimum profile drag coefficient.

C_{LO} is the lift coefficient for minimum profile drag and a is a constant for a given wing section.

Define A = fuselage and tail drag area in ft.^{2} where A is a ficticious area whose absolute drag coefficient is unity. That is A is equal to 1.28 times the equivalent flat plate drag area of fuselage and tail.

b = effective span of wing in ft.

S = actual wing area in ft.^{2}

Λ = effective aspect ratio. That is $\Lambda = \frac{b^2}{S}$

$B = \frac{\pi A}{b^2}$ where B is a non-dimensional parasite drag parameter

$h = \sqrt{\frac{2W}{Pb^2}}$ where h is a weight parameter, W being the gross weight in lbs. and P the air density in slugs.

$X = \pi C_{DOO}$ then $C_{DOO} = X/\pi$

$y = \pi a$ $\quad a = y/\pi$

C_{LX} = the lift coefficient for minimum

By minimising the expression for C_{DO}/C_L which is

$\frac{C_{DOO} + a(C_L - C_{LO})^2}{C_L}$ it is found that $C_{LX} = \sqrt{\frac{C_{DOO} + aC_{LO}^2}{a}}$

$= \sqrt{\frac{X + yC_{LO}^2}{y}}$ or $y = \frac{X}{C_{LX}^2 - C_{LO}^2}$

It is to be noted that C_{DOO} and C_{LO} can be read directly from the wing section profile drag polar. C_{LX} can be found by noting the point of tangency of a line drawn from the origin tangent to the polar.

$C_{Dp} = \frac{A}{S} = \frac{B\Lambda}{\pi} =$ fuselage and tail parasite drag coefficient.

$C_{Di} = \frac{C_L^2}{\pi\Lambda} =$ induced drag coefficient

Then the total drag coefficient, C_D, can be written as