DESIGN FOOTNOTES

Constant Margin of Stability

Several months ago, a method of CG location was outlined. The method and discussion was based on Fig. 1 below, which came from an article by Hank Cole in Dec. '47 Air Trails. This graph has since become available in a metal plate for tool box use and is designated NIMAS Chart number III.

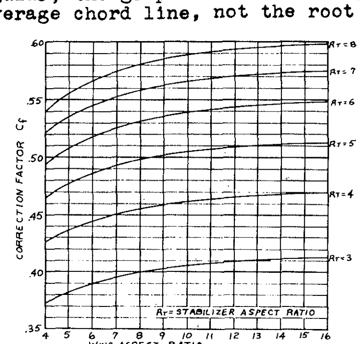
When this chart and discussion was printed, I had no experience in applying it to indoor. No doubt some of you suffered the same frustration as I did in applying this method to indoor models. The difficulty is that the chart assumes a fixed wing location, and ballast to locate the CG properly. Indoor models with wing location shifted to locate the CG properly force you to use a series of successive approximations - very tedious work.

So, why bother? The chart sets up a fixed margin of stability; different designs of similar weight adjusted to the same margin of stability fly in almost identical fashion. This is not necessarily true for models adjusted to have identical CG locations (such as 70% CG). To illustrate, consider two models of identical design but with different location of CG with respect to the thrust bearing. The model specs are: rectangular wing, 4" x 25" projected (100 sq. in., aspect ratio 6.25:1); stab, 2.8" x 12" (32.8 sq. in., A/R 4.3:1); 12" motor stick and 12" tail boom. In Fig. 2, Model A balances 6" from the nose, while model B balances 9" from the nose. Both models are assembled so the CG falls at 75%.

Let's figure the margin of stability on these models. Referring to Fig. 1 (Step 1) and Fig. 2, the tail moment of Model A is 17.9". C_f for both models (Fig. 1, Step 3) is .46. Computation of A.C. (aerodynamic center) for both models locates A.C. of model A 2.7" aft of the 25% chord; on model B the figure is 2.25". Both models have a 75% CG location; the margin of stability of A is .7"/4" = 17.5%, but on B the margin is .25"/4" = 6.25%. A 5% margin is about the most sensitive set-up which will fly well in average conditions, so model B is close to a critical adjustment and model A is too stable for best results.

As mentioned before, application of the principle of constant margin of stability is mathematically tedious. Fig. 3 illustrates a model (same design as A and B) with pertinent dimensions labelled to illustrate a graphical approach to constant stability margin. Tail moment arm will be 9.9" + 3" + Z. For this example, let the margin of stability = 5%. Thus, dimension "M" is .05 x 4" = .2", for all models built to this design. Compute A.C. for Z = 1" (A.C. = 2.10") and Z = 6" (A.C. = 2.85").

If Z = 1", Y = 11"; for Z = 6", Y = 6". Referring to Fig. 3, for the case of Z = 1", the CG will be 1.1" ahead of the wing TE. (AC is 3" - 2.10", or .9" ahead of the TE; M = .2", so the CG is 1.1" from TE). Thus, since Y is 11", X = 9.9". Similarly, for the case Z =6", X = 5.65". Graph these two points (Fig. 4) and connect these points with a straight line. This line is the locus of all practical locations for the wing trailing edge, given the condition that the stability margin is 5% of the wing average chord. In the case of models with flying surfaces not rectangular, the graph is the locus of locations of the 100% average chord line, not the root chord.



METHOD FOR DETERMINING POSITION OF C.G.

STEP I Measure tail moment arm between 25% point on the average chord of wing and stab. AV. CHORD = Area/Span

STEP II Find Aspect Ratio of Wing and Stab. Aspect Ratio = Span/Av. Chord or Span^2/Area

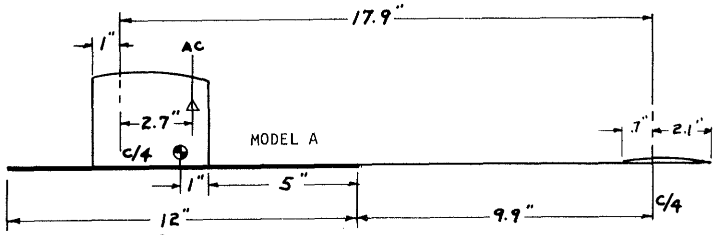
STEP III Find C_f from graph

STEP IV Find distance from 25% point of wing to A. C. A.C. = $\frac{\text{stab area}}{\text{wing area}}$ x Tail Mom. Arm x Cf

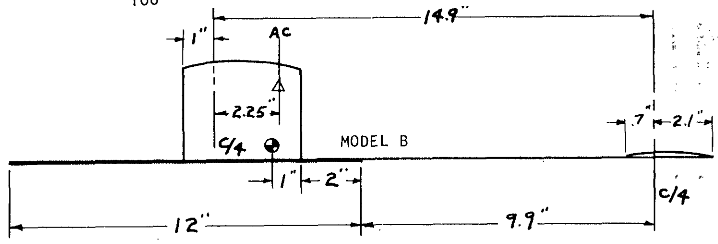
STEP V Locate C.G. 25% of average chord ahead of A.C.

Fig. 1

To summarize, compute the factors of Fig. 4, using a fixed stability margin. Balance the model, complete with prop and motor but minus wing, and measure distance X. Read Y from the graph and locate the wing TE accordingly. All models of similar size and weight, with the same margin of stability, will react to gusts and rafter-banging in very similar fashion. Constant stability margin is far more reliable for insuring good performance, in my opinion, than a specified CG location with regard to the wing.

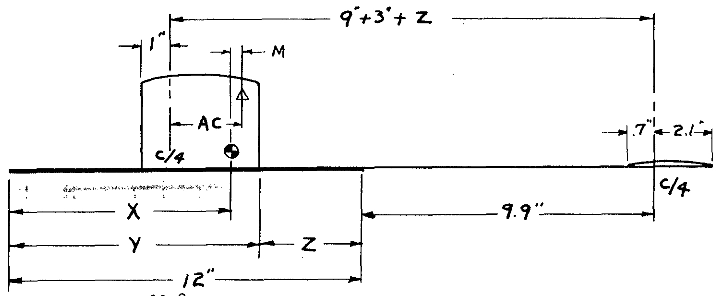


AC = $\frac{32.8}{100}$ x 17.9 x .46 = 2.7 CG is .7"←AC



AC = $\frac{32.8}{100}$ x 14.9 x .46 = 2.25 CG is .25"←AC

Fig. 2



AC = $\frac{32.8}{100}$ x 13.9 x .46 = 2.1 (Z = 1")

AC = $\frac{32.8}{100}$ x 18.9 x .46 = 2.85 (Z = 6")

Fig. 3

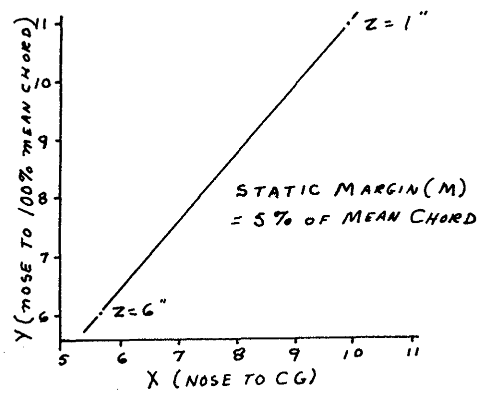


Fig. 4

ROME - THE PICTURE STORY

The pictures on page 5 were made available by Jim Richmond (pictures taken by a member of the Italian Aero Club) and by Eduard Chlubny of Czechoslovakia.

Top Row: Gunter Maibaum & Werner Wetzel (Germany); Clarence Mather; Gabriel Leopold (Yugoslavia).
Middle: Al Rohrbaugh (US) and Egizio Corazza (Italy); the Czech team - Jiri Sitar, Jiri Kalina, Eduard Chlubny.
Bottom: Hans Beck (Germany); Teodor Strasberger and Gabriel Leopold (Yugo); Manfred Koller (Austria).