Readers' Forum

Brief discussions of previous investigations in the aerospace sciences and technical comments on papers published in the AIAA Journal *are presented in this special department. Entries must be restricted to a maximum of 1000 words, or the equivalent of one* Journal *page including formulas and figures. A discussion will be published as quickly as possible after receipt of the manuscript. Neither the AIAA nor its editors are responsible for the opinions expressed by the correspondents. Authors will be invited to reply promptly.*

Comment on "Generic Approach to Determine Optimum Aeroelastic Characteristics for Composite Forward-Swept-Wing Aircraft"

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REFERENCE 1 presents a potentially useful approach to further understanding the complexities of structural tailoring for forward swept wing divergence. However, since Ref. 1 retraced a number of developments that previously appeared in Refs. 2 and 3, little space was available for a discussion of results or an examination of conclusions. In addition, Ref. 1 contains a number of technical developments and comments, some of which are important enough to warrant further examination and clarification. It is the purpose of this commentary to assist Dr. Oyibo and other interested readers by clarifying some of the issues raised by his work.

The aeroelastic model chosen by Dr. Oyibo in his development was originally developed and used by the present writer, with ample assistance from the archival literature. The structural model has a potential deficiency, since chordwise rigidity, in the form of stiff ribs, is assumed to be present. While this is a standard approach in conventional aeroelastic problems and may lead to little error for isotropic or orthotropic plates, considerable error in estimating cross-sectional stiffness and stiffness cross-coupling of anisotropic plates may be incurred if the assumption of chordwise rigidity is unfulfilled.[4,5] This will explain why the parameter ϵ, defined in Ref. 1 to reflect a Poisson's ratio effect, has little discernable effect on results. As a result, the term "generic," used in the title appears to be inappropriate.

After a brief discussion of 17 figures containing numerous parameter variations, Ref. 1 states: "Therefore, if these predictions are correct, this analysis has modified some of the conclusions of Ref. 2." However, the reader is not enlightened as to which conclusions have been modified. Let us list the conclusions from Ref. 2 and attempt to discern those that Ref. 1 seems to have modified.

"1) The elastic coupling between bending and torsion, introduced by the laminated material through the parameter K, can successfully negate the undesirable influence of forward sweep on wing divergence for large forward sweep angles.

"2) The ratio K/GJ is a very important parameter to consider when designing a forward swept wing structure. This ratio should be tailored such that it has a relatively large negative value.

"3) Wing taper is important to the determination of the divergence speed where such a speed actually exists. However, wing taper appears to be of little importance as a parameter influencing the design of a divergence free wing.

"4) An optimal orientation for wing divergence performance appears to occur when the lamina fibers are aligned at angles of 10-15 deg forward of the swept wing box beam reference axis."

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Certainly Ref. 1 has redemonstrated the validity of conclusion 1; item 3 was not addressed in Ref. 1. Although conclusions 2 and 4 belong in the same category, they are presumably the "some conclusions" called into question in Ref. 1, since Dr. Oyibo concludes that "divergence can be eliminated for a forward swept wing whose fiber orientation angles are swept back relative to the spanwise reference axis." If true, this is a startling new result, since it is in disagreement with a number of previous research findings. The disagreement is easily resolved since Dr. Oyibo appears to have overlooked the fact that the angle θ used in his development to define laminate properties is both a fiber angle and a transformation angle. As a result, the lamina stiffness coefficients Q_{ij} are periodic. When the definitions Q_{11} and Q_{22} are interchanged, the "optimum" θ orientation in Ref. 1 changes by 90 deg from a sweptforward orientation to a rearward swept direction. Unfortunately, it is not the fibers that are being sweptback, but rather the matrix direction. The fibers are still sweptforward and the wing still washes out. The apparent error lies in not explaining why the optimum orientations for divergence elimination appear to be about 90 deg apart when the parameter r_i is inverted and perhaps not understanding the physical nature of divergence suppression with aeroelastic tailoring. As a result, this writer believes that the conclusions given in Ref. 2 are supported, rather than modified, by Ref. 1.

References

[1]Oyibo, G. A., "Generic Approach to Determine Optimum Aeroelastic Characteristics for Composite Forward-Swept-Wing Aircraft," *AIAA Journal*, Vol. 21, Jan. 1984, pp. 117-123.

[2]Weisshaar, T. A., "Divergence of Forward Swept Composite Wings," *Journal of Aircraft*, Vol. 17, June 1980, pp. 442-448.

[3]Weisshaar, T. A., "Aeroelastic Stability and Performance Characteristics of Aircraft with Advanced Composite Sweptforward Wing Structures," AFFDL-TR-78-116, WP AFB, Ohio, Sept. 1978.

[4]Weisshaar, T. A. and Foist, B. L., "Vibration and Flutter of Advanced Composite Lifting Surfaces," AIAA Paper 83-0961, May 1983.

[5]Jensen, D. W. and Crawley, E. F., "Comparison of Frequency Determination Techniques for Cantilevered Plates with Bending-Torsion Coupling," AIAA Paper 83-0953, May 1983.

Reply by Author to T. A. Weisshaar

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REFERENCE 1 utilizes a rather powerful mathematical tool for exploring an important class of problems in anisotropic aeroelasticity and revealed the multivariable nature of aeroelastic tailoring. A fundamental aspect of the proposed tool has been used previously by others to establish that steady rigid-body aerodynamic coefficients are basically functions of Mach and Reynolds numbers, and was also used to formulate the historic Einstein's Special Relativity theory.[2] Therefore, the possibility of obtaining startling new results as published in Ref. 1, which appears to have triggered Prof.

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Weisshaar's Comment, did not come as a total surprise to the author.

Before proceeding to discuss Prof. Weisshaar's arguments and conclusions, it might be worthwhile to explain to readers what has been referred to in his Comment as "a number of developments that previously appeared in Refs. 2 and 3." The aeroelastic model used in Ref. 3, which is similar to that used by Housner and Stein,[4] is basically a product of the generalized Hooke's law and the bending-torsion displacement assumptions, both of which are well documented in the literature. Therefore, the claim that "the aeroelastic model chosen by Dr. Oyibo in his development was originally developed and used by the present writer" is inaccurate.

Prof. Weisshaar's argument that the term "generic" used in the title of Ref. 1 is "inappropriate" just because the generalized Poisson's ratio has minimal effects on the divergence boundaries (due to the chordwise displacement assumptions) is inapplicable because 1) the approach used in Ref. 1 is independent of displacement assumptions, and 2) the results of Ref. 1 are generic in the sense that they are true for *all* composite materials, not just for a sample composite material.

So that readers may readily verify that the author's published comments, in which he stated that some calculations of Ref. 3 are modified by those of Ref. 1, may have been an understatement, Fig. 1 is reproduced here from Ref. 1. First of all, Ref. 3 shows clearly that, according to Prof. Weisshaar's theory, divergence can only be precluded for $\theta > 90$ deg, i.e., only for fibers oriented forward of the spanwise reference axis. Figure 1a clearly disproves this conclusion by showing that at $\theta = 5$ deg (< 90 deg) divergence is capable of being precluded. Prof. Weisshaar's argument about interchanging Q_{11} and Q_{22} is also inapplicable since the range of r is constant ($0 < r \leq 1$) throughout Ref. 1. For instance, Figs. 1a and 1b show the divergence free-sweep angles for forward and backward swept fibers of 5 and 95 deg, respectively, which are 90 deg apart. It seems clear that the range of r for $\theta = 5$ deg is not inverted for $\theta = 95$ deg. Therefore, it is hard to see how the r-inversion argument could be used to compare the trends at $\theta = 5$ and 95 deg. Notice also that if $D^* = 0.319$, and $r = 0.314$, the results of Ref. 3 are recovered from the figures in Ref. 1 (including those reproduced here). Therefore, if his argument were correct this trend would have been visible in his analysis.[3] The claim in Ref. 3 that the maximum divergence-free forward-sweep angle is about 49 deg (at $\theta = 102$ deg) is inaccurate since it is clearly seen in Fig. 2 and Fig. 14 of Ref. 1 that divergence-free forward-sweep angles of 62 deg and over 80 deg are possible at $\theta = 102$ deg and $91 \leq \theta \leq 95$, respectively. Therefore, the conclusion that "an optimal orientation for wing divergence performance appears to occur when the lamina fibers are aligned at angles of 10-15 deg forward of the swept wing box beam reference axis" in Ref. 3 appears to be correct only for the class of parameters examined.

The author wishes to point out that Prof. Weisshaar should be complimented for his very valuable earlier work.[3] However, it should also be noted that, in the spirit of recognition that the state of the art does not stand still, the author did not criticize the results of any earlier investigators, but simply pointed out that his own contribution provided a generic approach which adds to the general understanding of the diveregence phenomenon. Instead of obtaining particular solutions based on a single-parameter representation, as was done by all previous investigators, the author demonstrates that there are generic parameters which have physical meaning and hence give the aeroelastician a wider range of possibilities in which acceptable practical solutions are to be found while avoiding divergence. For example, in Fig. 1 the author has plotted Prof. Weisshaar's particular solutions which appear as isolated points on his own field of solutions.

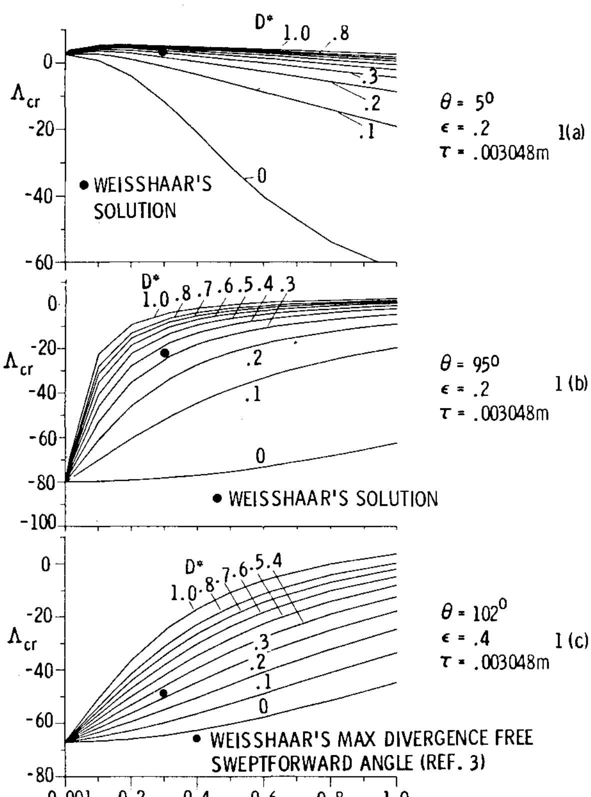

Fig. 1 Divergence free sweep angle vs r.

References

[1]Oyibo, G. A., "Generic Approach to Determine Optimum Aeroelastic Characterisitics for Composite Forward-Swept-Wing Aircraft," *AIAA Journal*, Vol. 21, Jan. 1984, pp. 117-123.

[2]Lieber, L., *The Einstein's Theory of Relativity*, Holt, Rinehart and Winston, New York.

[3]Weisshaar, T. A., "Divergence of Forward Swept Composite Wings," *Journal of Aircraft*, Vol. 17, June 1980, pp. 442-448.

[4]Housner, J. M. and Stein, M., "Flutter Analysis of Swept-Wing Subsonic Aircraft with Parameter Studies of Composite Wings," NASA TND-7539, Sept. 1974.

Comment on "Doublet-Point Method for Supersonic Unsteady Lifting Surfaces"

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TWO comments on Ref. 1 are made to emphasize the simplicity and generality of area-averaged downwash or doublets in lifting surface modeling.

First, steady-state area integration of an x/y^2R function can be approximated in a particularly general way. This is illustrated with Eq. (1a), which is based on Fig. 1 and the definitions of Eqs. (1b-1f). First the x integration was completed. The y integration was then replaced by a summation-integration. This computationally efficient form can replace Eqs. (6-10) of Ref. 1. It applies to either unswept or swept parallelogram patches, may be used at any Mach number through the use of Eq. (1f), and may be used for the influence between any two patches. N must be an odd integer.

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