Reply by Author to P.A.A. Laura

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THE author appreciates Dr. Laura's kind comments about his paper.[1] His discussion on the "reduction" methods is also very interesting. What follows is basically a comparison between the reduction approach and the approach proposed in Ref. 1 and related works.[2-4]

For almost half a century, numerous investigators, including those mentioned in the comment, have attempted to simplify and understand the mechanics of anisotropic plates, using some form of affine transformations. In the process, parameters wholly or partially equivalent to those proposed in Ref. 1 were defined. Curiously, no one seemed to realize that these parameters are the key to undetstanding the physics of anisotropic problems. While there is no unique approach to defining the parameters, such an exercise should aspire to minimize the efforts of understanding the proper physical trends in anisotropic problems.

The reduction method provides an efficient means of obtaining solutions to anisotropic problems if the isotropic solutions exist. The drawbacks include its dependence on isotropic solutions, boundary condition constraints, and, more importantly, the fact that the end results (solutions) are still in terms of the numerous anisotropic elastic constants, whose relative importance and bounds are unknown, resulting in an inevitable obstruction of the physical insight to be acquired from the analysis. The approach proposed in Ref. 1 and other related works,[2-4] on the other hand, is independent of isotropic solutions and boundary conditions. Furthermore, the reduction in the number of elastic constants and the fact that the resulting new parameters are the generalized forms of their isotropic counterparts, seem to simplify the physics of the problems significantly.

A similarity rule approach proposed by Brunelle[5] for some boundary-value problems is basically the equivalent of the reduction method in the affine space. Like the reduction method, it is very useful, but restricted to certain boundary-value problems and assumes the existence of a solution (isotropic or an anisotropic). However, unlike the reduction method, the physics of the problems is clearly exposed by this approach.

The increasing popularity of anisotropic materials in engineering designs makes maximum physical understanding of anisotropic problems very desirable. In a recent effort toward achieving such a goal, Librescu[6] presents an elaborate treatment of anisotropic and heterogeneous panel flutter problems in the physical space. A view of these problems in the affine space should greatly enhance their physical understanding. With reference to the approximate mode shapes for the clamped or rotation-restrained boundary conditions, proposed by Laura[7] et al., it should be pointed out that based on their accuracy (shown in Ref. 7), they should also be very useful in the affine space because of their relative simplicity.

In concluding, it may be worthwhile to point out that the use of affine transformations in complex problems is expanding. For example, Trevino[8] has recently analyzed some nonstationary random processes in an affine space where they are reduced to "stationary" random processes.

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Reply by Authors to W. P. Rodden

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THE method proposed in Ref. 1 is based on the idea of a *point* lift force which can be obtained mathematically by assuming Dirac delta function distributions of the pressure differential on a thin wing. The issue raised in the first paragraph of the Comment of Dr. Rodden concerns the cumbersome r^{-2} singularity of the pressure kernel where r is a spanwise distance between the doublet (sending) point and the upwash (receiving) point. This singularity appears independently of the reduced frequency. In the DLM,[2] one is forced to use the VLM (which differs from the DLM scheme for the unsteady part of the kernel) to evaluate this singularity, probably due to the inconvenient form of the kernel function. The present authors suppose that this may be one of the reasons inhibiting the extension of the DLM to the supersonic case where the VLM is not as successful as in subsonic flows. Development of our DPM for supersonic flows has been done recently.[3]

It is true that a single element in our method has no concern with the swept geometry of the element since its lift is represented by only a single concentrated force. It does not mean, however, that the method fails to include the effect of swept wings. This is clear from a result presented in Ref. 1 for a 35 deg swept-back wing where the DPM results are compared to those of the DLM.

Second, as stated by Dr. Rodden, the authors also do not think that their method has a substantial advantage over the

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DLM vis-à-vis accuracy. The advantage is primarily in its efficiency and consistency. It should be noted, however, that a set of bound vortices is an approximation of the real lift distributions and that an evaluation of the unsteady part of the kernel in the DLM must be avoided at a point $r=0$ where the upwash has a maximum value if the streamwise coordinate is fixed.

Third, as mentioned in Ref. 1, we discussed the method in nondimensional variables. So is the reduced frequency. Since the semichord length b of the root chord and the uniform flow speed u have been used to nondimensionalize length and velocity, time is nondimensionalized by b/u. Therefore, the reduced frequency is based upon b.

Finally, although only the coplanar case was discussed in Ref. 1, no special difficulty is anticipated for nonplanar wings. The kernel for nonplanar wings can also be evaluated by the form of the integral function presented in Ref. 4, which has been utilized in Ref. 1. When the vertical distance between a plane of doublet points an the upwash point is a finite value, the singularities at $r=0$ do not appear any longer.

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