$\Delta L/T$. However, no detailed flowfield surveys have been presented in Refs. 4-6 to substantiate this conclusion.

Acknowledgment

This work was supported by NASA Langley Research Center under Contract NAS1-14193-40.

References

[1] Kuhlman, J.M. and Warcup, R.W., "Experimental Investigation of Jet-Induced Loads on a Flat Plate in Hover Out-of-Ground Effect," NASA CR-159004, Feb. 1979.

[2] Margason, R.J., "Review of Propulsion-Induced Effects on Aerodynamics of Jet/STOL Aircraft," NASA TN D-5617, Feb. 1970.

[3] Gentry, G.L. and Margason, R.J., "Jet Induced Lift Losses on VTOL Configurations Hovering In and Out of Ground Effect," NASA TN D-3166, Feb. 1966.

[4] Kuhlman, J.M. and Warcup R.W., "Effects of Jet Decay Rate on Jet-Induced Loads on a Flat Plate," *Journal of Aircraft*, Vol. 15, May 1978. pp. 293-297.

[5] Kuhlman, J.M., Ousterhout, D.S., and Warcup, R.W., "Experimental Investigation of Effect of Jet Decay Rate on Jet-Induced Pressures on a Flat Plate," NASA CR-2979, April 1978.

[6] Kuhlman, J.M., Ousterhout, D.S., and Warcup, R.W., "Experimental Investigation of Effects of Jet Decay Rate on Jet-Induced Pressures on a Flat Plate: Tabulated Data," NASA CR-158990, Nov. 1978.

[7] Keffer, J.F. and Baines, W.D., "The Round Turbulent Jet in a Cross-Wind," *Journal of Fluid Mechanics*, Vol. 15, Pt. 4, April 1963, pp. 481-497.

[8] Kamotani, Y. and Greber, I., "Experiments on a Turbulent Jet in a Cross Flow," NASA CR-72893, June 1971.

[9] Fearn, R.L. and Weston, R.P., "The Induced Pressure Distribution of a Jet in a Crossflow," NASA TN D-7916, July 1975.

[10] Fearn, R.L., and Weston, R.P., "Vorticity Associated with a Jet in a Cross Flow," *AIAA Journal*, Vol. 12, Dec. 1974, pp. 1666-1671.

[11] Ousterhout, D.S., "An Experimental Investigation of a Cold Jet Emitting from a Body of Revolution into a Subsonic Free Stream," NASA CR-2089, Aug. 1972.

[12] Ziegler, H. and Wooler, P.T., "Analysis of Stratified and Closely Spaced Jets Exhausting into a Crossflow," NASA CR-132297, Nov. 1973.

[13] Moller, P.S. and Elliott, R.L., "Base Drag of a Thick Annular Jet," *Journal of Aircraft*, Vol. 9, July 1972, pp. 451-455.

Technical Comments

C80-107

Comment on "Calculation of Rotor Impedance for Articulated-Rotor Helicopters in Forward Flight"

(A)

David A. Peters*
Washington University, St. Louis, Mo.

(C79-001) (no ref) 7

THE paper by Kato and Yamane (*Journal of Aircraft*, Vol. 16, ~~July 1979~~, pp. 470-476) is very interesting and certainly adds to our understanding of rotor impedance in forward flight. There are two oversights in the paper, however, that should be corrected. First, the introduction states that in their Ref. 2[1] "numerical results are given in terms of steady-state thrust and moment derivatives for steady ($\omega = 0$) shaft incidence as well as blade pitch controls." To the contrary, one will find that Figs. 4-13 of Ref. 2 give theoretical and experimental unsteady frequency response due to unsteady shaft incidence ($\omega \neq 0$) and unsteady pitch controls.

Second, Fig. 6 of the paper by Kato and Yamane indicates that the H-force variation with pitching rate approaches a constant as ω goes to zero. In forward flight, however, a steady value of pitch incidence α gives a nonzero change in H-force. Therefore, the pitch incidence derivative $\partial H/\partial \dot{\alpha} = (1/i\omega)\partial H/\partial \alpha$ must go to infinity as ω goes to zero. The source of this discrepancy may be in Eq. (6) of the paper, in which it appears that the contribution of pitch angle $U\alpha$ is missing from the vertical velocity H_a.

On the other hand it should be emphasized that the above oversights are small, and do not negate the overall quality of the paper.

Received Aug. 6, 1979.

Index categories: Helicopters; Vibration; Aeroelasticity and Hydroelasticity.

*Professor, Department of Mechanical Engineering. Associate Fellow AIAA.

References

[1] Peters, D.A., "Hingeless Rotor Frequency Response with Unsteady Inflow," NASA SP-352, Feb. 1974, pp. 1-12.

00018
00033
80001

C80-108

Reply by Authors to D.A. Peters

Kanichiro Kato* and Takashi Yamane†
University of Tokyo, Tokyo, Japan

PROFESSOR Peters's comments and his interest in our paper are greatly appreciated. We would like to offer the following comments.

Received Oct. 25, 1979.

Index categories: Helicopters; Vibration; Aeroelasticity and Hydroelasticity.

*Professor, Department of Aeronautics.
†Graduate Student, Department of Aeronautics.

In the first part of his comments, Professor Peters is half correct. We had realized that he had given unsteady control responses in Ref. 1. But a confusion occurred in our final draft, due to our intention to refer to both Refs. 1 and 2 simultaneously. We express our regret in this respect. Concerning unsteady shaft responses, he gave results in Fig. 9 (and only in Fig. 9) of Ref. 1, p. 10. However, those results concern the case of hover and, since our paper discusses forward flight, correction in this respect would not be necessary.

Professor Peters's second comment is probably due to his misunderstanding of our notations. Our independent variables are hub-fixed velocities (U,V,W) and angular velocities (P,Q,R). Let us denote the hub pitch angle by α. The α derivatives can be related to ours in the following manner: $\partial H/\partial\alpha \simeq U\partial H/\partial W$, $\partial H/\partial\dot{\alpha} = \partial H/\partial Q$, where $\partial H/\partial\alpha$ is a partial derivative at constant $\dot{\alpha}$ while $\partial H/\partial\dot{\alpha}$ is at constant α. If these definitions for partial derivatives are applied, the relation $\partial H/\partial\dot{\alpha} = (1/i\omega)\partial H/\partial\alpha$ does not hold since α and $\dot{\alpha}$ are dependent in this equation. What is meant by $(1/i\omega)\partial H/\partial\alpha$ is not $\partial H/\partial Q$, but $U(\partial H/\partial\dot{W})$, the H-force due to vertical acceleration which becomes infinity as ω goes to zero. Physically, $\partial H/\partial Q$ (when $\omega = 0$) is the main source of helicopter damping in pitch (conventionally noted as stability derivative M_q or M_θ) and is never infinite. Moreover, the $U\alpha$ term is *not* missing in our formulation. It is counted as W (hub vertical velocity) which is contained in Eq. (6) of our paper.

References

[1] Peters, D.A., "Hingeless Rotor Frequency Response with Unsteady Inflow," NASA SP-352, Feb. 1974, pp. 1-12.

[2] Peters, D.A. and Ormiston, R.A., "Flapping Response Characteristics of Hingeless Rotor Blades by a Generalized Harmonic Balance Method," NASA TN D-7856, 1975.