

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

Acknowledgment

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Technical Comments

C80-107

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

David A. Peters*

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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. 2¹ "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 $\partial H / \partial \dot{\alpha} = (1/\omega) \partial H / \partial \alpha$ 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.

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

Reply by Authors to D.A. Peters

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

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Index categories: Helicopters; Vibration; Aeroelasticity and Hydroelasticity.

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Index categories: Helicopters; Vibration; Aeroelasticity and Hydroelasticity.

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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: $\partial H / \partial \alpha \approx U \partial H / \partial W$, $\partial H / \partial \dot{\alpha} = \partial H / \partial Q$, 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 $M_{\dot{\theta}}$) 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.

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