T_y. (Note that his $\sin 2\theta \cos\phi$ is better restored to direction cosine form before comparing.) Similarly, it is found that L_2 = his T_x, and L_3 = his $-T_z$, as should be the case because of different axis orientation conventions.

In summary, Eq. (7) is a convenient matrix form for the gravitational torque in a completely general field. It reduces to Schlegel's under the conditions he assumes, but is somewhat more general in that it does not imply that body axes are principal axes, and it allows the body orientation to be measured from a frame with one more degree of rotational freedom. Furthermore, the body orientation is not tied to any specific parametrization of the direction cosine matrix.

I fully agree that the magnitude of the torque correction from oblateness is very small, but I cannot concur with Schlegel that it yet has been established that it "can be safely ignored save in high precision studies." Although I suspect he is correct, it should be recognized that the oblateness effect will appear not only as an "external torque" in the dynamical equations, but also as a parametrix excitation. Under these conditions it is conceivable that it results in changes in stability characteristic or response amplitude to a degree quite unanticipated from its numerical magnitude. I believe that further studies are required to determine whether this kind of behavior can arise in situations which are of practical interest.

References

[1] Schlegel, L. B., "Contribution of Earth Oblateness to Gravity Torque on a Satellite," *AIAA Journal*, Vol. 4, No. 11, Nov. 1966, pp. 2075–2077.

[2] Pengelley, C. D., "Gravitational Torque on a Small Rigid Body in an Arbitrary Field," *ARS Journal*, Vol. 32, 1962, pp. 420–422.

Comment on "Large Deflection of Rectangular Sandwich Plates"

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THIS Comment concerns the statement of the boundary conditions presented by the authors[1] in their Eq. (3) and rewritten below in a different form:

$$\text{at } \xi = \pm 1 \quad U = V = 0 \qquad W = \alpha = \beta = \partial W/\partial \xi = 0$$

$$\text{at } \eta = \pm 1 \quad U = V = 0 \qquad W = \alpha = \beta = \partial W/\partial \eta = 0$$

The equations involving U and V represent possible statements of the necessary two boundary conditions for the in-plane system. The equations involving W, α, β, and $\partial W/\partial \xi$ ($\partial W/\partial \eta$) would then represent four boundary conditions for the bending. However, plate bending is described by a sixth-order set of equations, so that there can be just three boundary conditions on each edge. The extra and incorrect boundary conditions are the following:

$$\text{at } \xi = \pm 1 \qquad \partial W/\partial \xi = 0$$

$$\text{at } \eta = \pm 1 \qquad \partial W/\partial \eta = 0$$

The stress-strain-displacement relations for transverse shear are

$$S_x/G_c h = \gamma_{xz} = \alpha + \theta\, \partial W/\partial \xi$$

$$S_y/Q_c h = \gamma_{yz} = \beta + \theta\, \partial W/\partial \eta$$

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where S_x and S_y are the transverse shear forces, and γ_{xz} and γ_{yz} are the transverse shear strains. These equations show that requiring both α and $\partial W/\partial \xi$ to vanish forces zero transverse shear strain at the boundaries $\xi = \pm 1$. Since the edge transverse shear strains are not zero for a sandwich plate, the center deflection will actually be larger than reported by the authors.

Reference

[1] Kan, H. and Huang, J., "Large Deflection of Rectangular Sandwich Plates," *AIAA Journal*, Vol. 5, No. 9, Sept. 1967, pp. 1706–1708.

Reply by Author to C. V. Smith

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SINCE we can always combine α with $\partial W/\partial \xi$ and β with $\partial W/\partial \eta$ to obtain transverse shear strains, boundary conditions (3) of our Note[3] are not independent. They are correct conditions, since the solutions of our Note are given for a rectangular sandwich plate with rigidly clamped edges. The conditions characterizing a rigidly clamped edge parallel to the coordinate-axes are zero deflection and zero slope of the middle surface along the edge and zero rotation of the cross section making up the boundary. These requirements certainly force the transverse shear strain to zero at the boundaries. It can be easily seen by considering the deflection of a cantilever sandwich beam due to deformation associated with the shear stress as shown in Fig. 1. Element A, on the neutral axis, which is originally rectangular, changes into a rhombus, but element B near the clamped end remains unchanged. Hence we can simply assume that the transverse shear strain equals to zero at the restrained end.

In the early works of Hoff,[1,2] similar boundary conditions have been used for the bending of a cantilever sandwich beam and bending of rectangular sandwich plate with edges clamped. The transverse shear strains vanish at the restrained boundaries for both cases.

For the sake of simplicity, we can always relax the boundary conditions to some extent by letting the edge slopes of the middle surface of the plate be different from zero. Naturally this assumption will lead to slightly larger center deflection.

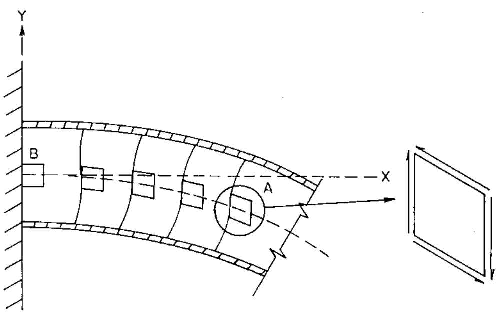

Fig. 1 Deflection of cantilever sandwich beam.

References

[1] Hoff, N. J., *The Analysis of Structure*, Wiley, New York, 1956, pp. 180–193; also Hoff, N. J. and Mantner, S. E., "Bending and Buckling of Sandwich Beams," *The Journal of the Aeronautical Sciences*, Vol. 15, No. 12, 1948, p. 707.

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