Stress Analysis of a Helical Coil

ROBERT SCHMIDT. It is rather gratifying to see the fairly extensive numerical data, useful in the design of helical springs of rectangular cross section, presented in the paper.

The writer has noticed two trivial misprints in the paper; namely, a missing subscript in equation (21a) and the letter g instead of h in equation (29a). However, the most noticeable feature of the paper is the lack of references to previous works dealing with the same problem.

The first solution for the “pure” torsion of a torus of rectangular cross section was given by Michell [1] in the form of a stress function similar to the author’s. Tricomi [2] reconsidered the problem. Langhaar [3], only a few years ago, discussed and solved the problem again, presenting also a numerical example. His paper was published in this same JOURNAL. Sadowsky and Sternberg [4] discussed the history of the problem in a fairly complete manner. In addition, the work of Liesecke [5] and a paper by Wahl [6] may be mentioned.

References


Author’s Closure

The author appreciates the bringing to his attention the references given by Professor Schmidt. The “exact” solution of the helical coil stress problem was apparently done by Michell in 1899 and repeated (apparently unknowingly) by later authors. The simplifications to small index coils contained in the author’s paper, however, do not appear to have been done before.

A Digital Computer Program for the General Axially Symmetric Thin-Shell Problem

D. B. ROSSHEIM and C. A. HONIGSBERG. The authors have presented a useful summary of their development of a general computer program for thin shells of revolution subject to radially symmetric loading or temperature variation. Their success in the preparation of a generalized program of this type is a gratifying demonstration of the value of this approach to problems of heat transfer and stress analysis for shells.

The conclusion to the paper states that the program can be easily extended to include external rings, shell junctions, radial temperature variation, or concentrated loads. It would be inter-

6. The M. W. Kellogg Company, New York, N. Y. Fellow ASME.
7. The M. W. Kellogg Company, New York, N. Y. Mem. ASME.
existing to know what types of concentrated loads can be handled; also whether intersections of three surfaces of revolution can be treated. The latter problem has practical application for pressure vessels having an intermediate head with an abutting shell on each side, or a bottom head with a pressure shell on one side and a skirt on the other. Other desirable applications would be assemblies including flat heads under flexure connected to cylindrical shells.

A companion paper describes a technique for analyzing rotationally symmetrical irregular shapes with mechanical and thermal loading, allowing axial and radial thermal gradients. It would seem desirable that the accomplishments of the authors of both papers be brought together in a consolidated effort to provide a long-range comprehensive general treatment of surfaces of revolution under mechanical and thermal stresses, the objective being a collection of unified programs permitting selection and assembly for computer calculation of individual problems. It is hoped that an effort of this nature will receive the cooperative industry and government (National Science Foundation, Armed Services, Atomic Energy Commission, and so on) recognition and support which it deserves.

F. A. McClintock. The writer would like to welcome the appearance in the Journal of Applied Mechanics of papers based on computer solutions to problems such as this. As time goes on, more of the work in "applied mechanics" will be done by computers which will provide more economical solutions to problems with complex boundary conditions that can be obtained in other ways. The writer would like to ask the authors' opinion on the way in which such programs should be handled. Would a reasonable solution be for the Journal to print in full articles about programs of broad generality which are being presented for public use without restriction, copies of which are available on request, but to print in more limited form those which are proprietary because of their sponsorship? Should the Society undertake to develop a current index of available programs in applied mechanics, or are other organizations already providing this service?

Authors' Closure

Our thanks are extended to Messrs. Rossheim and Honigsberg for their kind remarks. As our thin shell analysis will only consider loads which are symmetrically distributed about the axis of rotation, a concentrated load will appear as an intense ring load composed of shear and in-plane forces and/or meridional moments, unless, of course, the load occurs at the apex of a closed shell. With the present computer program, ring loads may be applied at any portion of a given shell of revolution if the shell is divided into two parts at the location of the ring load. The ring load must be divided and superimposed on the internal loads, forces, and moments as boundary loads on the separate shells. The division of the ring load must be made in a manner to assure compatibility at the juncture (i.e., the rotation and radial displacement must be equal at the so-called "ring load boundary"). This is done by determining the edge influence coefficients of either shell at this juncture (i.e., the deformation of the shell edge when a unit load is applied). These influence coefficients can then be used to solve a series of linear, algebraic equations which consider compatibility and equilibrium of the shell juncture.

The juncture of three or more shells is handled in a similar manner. For each shell edge at the juncture, the reaction of the shell to unit shear, direct forces, and meridional moments is determined. Once the edge influence coefficients are known,

\[ w^v + 12(1 - v^2)N^v a^2 = -p/D + \varphi N^v a D \]

for a homogeneous shell of thickness \( h \), instead of the author's equation (14), which, for this case, becomes

\[ w^v + 12(1 - v^2)N^v a^2 = -p/D + \varphi N^v a D \]

where

\[ D = E h^2/12(1 - v^2) \]

That is, it is reasonable to expect that there is always the effect, which is called the "beam-column effect" by the author, even in homogeneous shells. This effect, i.e., the term containing \( w^v \), is likely to vanish under certain conditions in the case of the multilayered cylindrical shells. It should be noticed that the \( w^v \)-term is small in comparison with the other terms.

The writer does not want to imply that the first equation of this discussion is more accurate than the second.

He also believes that a consistency in signs would not have been detrimental to the paper.

S. J. Becker. In this fine paper, the constant \( D \), unfortunately, is somewhat mysterious. There exists, however, a perfectly rational physical explanation for its existence which this discussor would like to add.

Since we deal with thin shells, we use the approximations that \( w \) is not a function of \( r \), and \( r \) varies so little from \( a \) that it can be replaced by \( a \) wherever this does not obviously lead to gross error. Thus, equation (3) for the hoop strain is a valid statement for all fibers of the shell; that is, the hoop strain is, at most, a function of \( x \).


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