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FINITE ELEMENT LARGE DEFORMATION ANALYSIS OF CORD-REINFORCED MEMBRANES

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ABSTRACT

Finite element programs are constructed for analyzing two and three dimensional membrane structures of a 'composite' material manufactured by embedding high modulus (e.g., nylon or steel) cords in a regular pattern in a matrix of low modulus (e.g., rubber) material. Such membranes, although constrained by the presence of high modulus cords, under some conditions of support, cord layout, and loading, can undergo large deformations comparable to those possible for matrix alone.

The finite element model simulates the real situation of a discretely and uniformly spaced network of cords embedded in a continuum of matrix material. The cords are modeled as constant-strain axial elements, whereas the matrix is discretized into constant-strain triangular elements. Full displacement compatibility therefore exists between the matrix and the cords. The matrix material is considered to obey the large-strain neo-Hookean elastic law, which is in contrast to the small-strain linear elastic behaviour assumed for the cords. The resulting problem belongs to large deformation nonlinear mechanics.

The programs are validated by experimental results [1] as well as by theoretical results obtained by assuming the cords to be inextensible. The problems for which this validation is carried out are: (i) plane rubber sheets reinforced with nylon and steel cords, subjected to simple extension, and (ii) closed-ends circular cylindrical rubber tubes reinforced with nylon cords, subjected to inflating pressure. It is shown that the constructed finite element programs do predict responses which match quite closely with the experimental data and observations. Also, the finite element results are similar to those obtained from the ideal inextensible cords theory.

The work may be found useful in modeling such applications as cord-reinforced tires and biological membranes like human skin.

REFERENCE

[1] Charrier, J.-M. (1970) Large Elastic Deformations of Some Cord-Reinforced Rubber Shells, *Rubber Chemistry and Technology*, Vol. 43, No. 2, pp 282-303.