Interlaminar stresses in doubly curved laminates

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5) Organizational unit: Departement Maschinenbau und Verfahrenstechnik, Institut für Mechanische Systeme (IMES), Ermanni, Paolo, permanni@ethz.ch, LZ=03507

6) Project leader(s):
   - Kress, Gerald, gkress@ethz.ch, Dep. Maschinenbau und Verfahrenstechnik, Inst. f. Design, Mat. und Fabrikation

7) ETH researcher(s): no entry

8) External researcher(s): no entry

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13) Project description:
Composite materials are increasingly often used in designs where moderately thick-walled curved shells appear. The stress states will then include interlaminar shear and normal stresses which, together with the low interlaminar strength, may initiate structural failure by delamination. Typical applications where such problems can occur are air intakes of formula one race cars which serve also as roll-bars to protect the driver, strongly curved regions of sailing yacht hulls, or machine tool frames. The stresses in curved unidirectional laminate are well approximated by using FEM with solid elements. When regions susceptible to interlaminar failure appear in larger structures, making three dimensional solid modeling necessary, the modeling as well as the computational effort may quickly exceed reasonable limits. This motivates the interest in simple models for interlaminar stress which can be used with shell elements for calculating. Shell elements calculating not only interlaminar shear but also interlaminar normal stress are not yet available in current commercial FEM programs. A new model finds an exact solution for the through-the-thickness distributions of the out-of-plane displacement and the interlaminar normal stress distribution. A basic version of it has been experimentally and numerically validated for the case of singly curved laminates. The research program aims at extending the model to include shear stress as well as doubly curved laminates. The model can be used as a pre- and post-processor for existing suited doubly-curved finite shell elements, filling the existing gap in computational tools for efficient interlaminar stress analysis of composite structures.

14) Popular description: no entry

15) Graphics:

Test specimen with delaminations

Figure 1: Test specimen with delaminations

Rene Roos (roosre@ethz.ch)

Interlaminar normal stress distributions
Figure 2: Interlaminar normal stress distributions

Dr. Gerald Kress (gkress@ethz.ch)

Interlaminar normal stress distributions: FEM and analytical models
16) Publications:


Figure 3: Interlaminar normal stress distributions
FEM and analytical models

Rene Roos (roosre@ethz.ch)

17) Links to important web pages: no entry