

Please send this report to the Secretary of the European Mechanics Council, Professor Bengt Lundberg, Dept of Mechanical Engineering, Luleå University of Technology, S-951 87 Luleå, Sweden, one month after the Colloquium

General

Euromech Colloquium No: 292

Title: Modelling of Shells with Nonlinear Behaviour

Chairmen: Prof. Dr.-Ing. W. Wunderlich

Place and country: Technical University of Munic, Germany

Dates: September 2.-4., 1992

Finance

The conference fee DM 90,- included Organization costs and Printings

Funding: DFG/DAAD: Organization costs and travel expenses

Accommodation (type and cost): DM 80,- per person and night, including full boarding.

Meals: _____

Participation

Total number of participants: 68

Distribution of participants by country:

Code	Country	Number	Code	Country	Number
A	Austria	<u>2</u>	I	Italy	<u>2</u>
B	Belgium	<u>-</u>	IRL	Ireland	<u>-</u>
BG	Bulgaria	<u>-</u>	N	Norway	<u>1</u>
CH	Switzerland	<u>1</u>	NL	Netherlands	<u>3</u>
CS	Czechoslovakia	<u>1</u>	P	Portugal	<u>-</u>
D	Germany	<u>37</u>	PL	Poland	<u>2</u>
DK	Denmark	<u>-</u>	R	Rumania	<u>-</u>
E	Spain	<u>2</u>	S	Sweden	<u>1</u>
F	France	<u>6</u>	SF	Finland	<u>-</u>
GB	Great Britain	<u>2</u>	YU	Yugoslavia	<u>-</u>
GR	Greece	<u>-</u>	SU	Soviet Union	<u>5</u>
H	Hungary	<u>-</u>	-	Others	<u>3</u>

Is there need of another colloquium on the same subject? Which year? 1994

Theory of Shells with Nonlinear and /or Anisotropic Material Behaviour

Scientific Report

EUROMECH COLLOQUIUM 292

Modelling of Shells with Nonlinear Behaviour

TU Muenchen, September 2.-4., 1992

The topic of this Colloquium received wide interest in the scientific community working in the field of shells. More applications were received than could be included in the Colloquium in a sensible manner. Nearly all of the invited scientists intended to present a paper and a lot of additional proposals were received. Thus, a consistent program could be arranged from the numerous interesting proposals for papers as a basis for the discussion of the main topics of the Colloquium. In summary 32 papers were given, about half of them from non-German participants.

The focus was directed on new trends and innovations of theoretical foundations of nonlinear shell theory and corresponding numerical solution algorithms, as well as on the nonlinear load carrying behaviour, in this case especially on imperfection sensitivity and safety against stability failure.

With respect to the geometrical nonlinear description of shells for arbitrarily large deflections and rotations a certain consolidation of the theoretical foundations can be observed. Due to the highly advanced numerical solution techniques – especially the finite element method – differential equations of arbitrarily complicated structure can be treated. Thus, there is no specific need for simplifications in the formulations any more. In the frame of small strain theory different kinds of basic assumptions – from continuum mechanics as well as from surface theories (Cosserat continuum) – lead to good results as was shown in some papers.

From the theoretical point of view as well as from the numerical solution techniques increasingly important are the polar decomposition of the deformation gradient and the introduction of rotations as primary unknowns in the field equations. In addition to other advantages this allows a consistent derivation of the stiffness for drilling degrees of freedom normal to the shell midsurface which are related to the membrane stresses, an important feature in calculations with the finite element method.

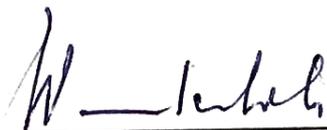
Actual developments were directed on models for large respective finite strain analysis of shells and the corresponding material laws. Another domain under intensive investigation is the extension of the classical shell theory for isotropic media to orthotropic and/or laminated materials. In these cases Reissner-Mindlin-type theories are applied and a deformation of the shell director is included.

As is well known the nonlinear load carrying behaviour of shell structures will be influenced mainly by their imperfection sensitivity. Small imperfections often lead to large deformations

in the critical postbuckling range and a drastic reduction of the limit load. The papers dealing with the safety against stability failure were mainly investigating the capabilities of the numerical simulation techniques to describe this phenomenon and their theoretical foundations. Of special importance is the definition of critical imperfection patterns to be used. In this field more realistic assumptions compared to the classical buckling mode patterns are under development. Among others a numerical technique was proposed to find the critical imperfection patterns on the basis of some kind of perturbation energy related to a variational principle.

In conclusion the Colloquium made clear that the present level of nonlinear shell theory and numerical modelling is very advanced and offers a broad spectrum of physical and mathematical applications. Also the more classical isotropic shell theories are extended to orthotropic and/or laminated shells for applications in aircraft and automobile industry, but also in structural engineering. In addition the consistent inclusion of nonlinear material behaviour for large strains and time dependent influences – from the up to now more continuum based material sciences – is a demanding challenge for shell analysts. And as the material nonlinear shell theory and analysis will become more important in the future, this could be a topic for a further Colloquium on shells in two or three years where these questions could be discussed in more detail.

Munich, November 2, 1992



(Prof. Dr.-Ing. W. Wunderlich)