EUROPEAN MECHANICS SOCIETY

Colloquium Final Report Form

Please send this report in electronic form to the Secretary General of EUROMECH, within one month after your Colloquium.

Title: **Mechanics of Fibre-reinforced Materials: Theory and Applications**

Colloquium: No **551** Dates and location: **September 2-5, 2013, University of Nottingham, UK**

Chairperson: **Professor Ray Ogden**

Co-Chairpersons: **Dr Kostas P. Soldatos and Professor Jose Merodio**

Is there need of another Colloquium on the same or a related subject? Which year?

Yes, probably in 2015/2016

Full registration fee: **£370, inclusive of accommodation and meals**

What other funding was obtained? **£7000 from the London Mathematical Society**

What were the participants offered? **Accommodation, meals, refreshments, travel expenses in a few cases**

Number of members of Euromech (reduced registration fee): **10**

Number of non-members of Euromech (full registration fee): **28**

Number of participants from each country:

Austria		Great Britain	18	Slovakia	
Belgium		Greece		Slovenia	
Bosnia		Hungary		Spain	4
Byelorussia		Ireland	3	Sweden	
Bulgaria		Italy	1	Switzerland	
Croatia		Latvia		Ukraine	
Czech Republic	1	Lithuania		Serbia	1
Denmark		Netherlands		Montenegro	
Estonia		Norway		Turkey	
Finland		Poland	1	Others	5
France	1	Portugal			
Georgia		Romania			
Germany	1	Russia	2	**Total**	38

List names of Applicants to EUROMECH: **separate list attached**

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Scientific Report
Please type your report on the following pages. Use additional pages if required. Put the date and your signature at the end.

Colloquium No. 551 Scientific Report

The colloquium focused on developments in the mechanics of fibre-reinforced materials, including theoretical, analytical and experimental developments and their applications. The main concern was with the linear and nonlinear elastic, viscoelastic and plastic behaviour of fibre-reinforced solids but also included fluid-like behaviour and constitutive modelling. The type of materials considered ranged from soft solids such as biological tissues and fibre-reinforced polymers to harder materials such as carbon-fibre or glass-fibre reinforced materials. There was particular interest in the effect of fibre reinforcement on material integrity and stability from both the static and dynamic perspectives.

The continuum theory of fibre-reinforced materials has largely been shaped by the contributions of members of the former Department of Theoretical Mechanics at the University of Nottingham and has its origins in the pioneering work of J. E. Adkins and R.S. Rivlin, published in 1955. Adkins became the Head of the Department of Theoretical Mechanics and the subject flourished in Nottingham under the leadership of A. J. M. Spencer, who was the successor of Adkins. The University of Nottingham was therefore a very appropriate venue for the Colloquium 551 on the *Mechanics of Fibre-Reinforced Materials: Theory and Applications*.

There were 38 participants from 14 countries and 32 presentations, including one plenary lecture by Professor Patrick Selvadurai (who gained his PhD with Spencer at Nottingham in 1971) from McGill University on the implications for fracture mechanics of flaw bridging in fibre-reinforced elastic materials. Application of the theory of fibre-reinforced materials to the mechanics of soft biological tissues was very well represented with eight talks, reflecting the enormous potential that the theory has to contribute to our understanding of the biomechanical behaviour of various parts of the human anatomy. Progress in the dealing with the theory and computation of cells, ligaments, arteries and the left ventricle was reported.

Several talks discussed the properties of fibre-reinforced composites, including both linearly and nonlinearly elastic multiphase composites, their macroscopic response and stability, the formation of kink bands and computational analysis of failure. In the context of the finite elastic deformations of fibre-reinforced materials the instabilities of tubes undergoing inflation, swelling or azimuthal shear were examined in a number of papers with particular reference to non-smooth solutions. Based on the theory of incremental deformations superimposed on a large deformation, the effect of strong fibres in a soft matrix on the incidence of surface wrinkling of a half-space was exposed.

Four talks dealt with the dynamics of strongly fibre-reinforced elastic plates, the propagation of weakly nonlinear waves elastic and the influence of initial stress on the properties of nonlinearly elastic materials and its effect on the characteristics of both plane and surface waves.

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Computational methods are required for the solution of specific boundary-value problems, particularly for situations where the geometry is not very simple, and computational methods featured in several talks. It was demonstrated in one talk that for anisotropic materials particular care is needed when using finite element packages that rely on the volumetric/deviatoric separation of the energy function since physically sensible results are not always achieved.

Much progress has been made in the nonlinear elasticity theory of fibre-reinforced materials in recent years, but it is clear that much more needs to be done. On the theoretical side, from the construction of constitutive laws informed by experimental data, particularly where residual stress is important, to the solution of realistic boundary-value problems, especially those where instabilities arise such as those associated with the onset of non-smooth deformations. Application of the theory is then need to address a variety of problems for particular material structures, in engineering where 'soft' material such as rubber is reinforced with strong flexible fibres or in the biomechanics of soft biological tissues where collagen provides the reinforcement amongst a diversity of softer 'matrix' materials. More data are needed for these types of materials so that we can more effectively derive realistic materials models, validate them and have confidence in them, and trust that the computed results are meaningful. That also requires reliable implementations of anisotropic models in finite element software. In conclusion, there is scope for considerable and diverse research in the nonlinear mechanics of fibre-reinforced materials.

EUROMECH Colloquium 551 was very successful. The organization was excellent and, apart from the scientific programme, which generated valuable discussions and led to new collaborations, a very friendly group of colleagues made for a collegial atmosphere, which was helped by the splendid social arrangements provided by our host in Nottingham, Kostas Soldatos.

R. W. Ogden

6 October 2013

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