

EUROMECH

EUROPEAN MECHANICS SOCIETY

Final Report

Please send this report to the Secretary-General of EUROMECH, within one month after the Colloquium.

EUROMECH Colloquium No: 360

Title: MECHANICS OF SANDWICH STRUCTURES

Dates and location: 13-15 May 1997 ; St Etienne France

Chairman: Alain Vautrin

Co-Chairman: Antonio Torres Marques

Is there need of another Colloquium on the same or a related subject? Which year? 4 - 5 years

Full registration fee: 2 300 FF (including the proceedings, banquet)

What other funding was obtained? yes (different financial supports and support from the school)

What were the participants offered? Participants have been provided with a scientific package that comprised the Colloquium programme, the *extended abstracts* of the presentations (a two or three page abstract per paper provided by the authors after the acceptation) and the list of session chairmen. The list of participants has been released at the end of the Colloquium. *Extended papers* reviewed by the scientific committee will be published in 1998 by KLUWER Academic Publishers.

Number of members of EUROMECH (reduced registration fee): 15

Number of non-members of EUROMECH (full registration fee): 59

Number of participants from each country:

Austria	1	Germany	3	Romania	_____
Belgium	5	Great Britain	2	Russia	2
Byelorussia	_____	Greece	1	Slovakia	_____
Bosnia	_____	Hungary	_____	Slovenia	_____
Bulgaria	_____	Ireland	_____	Spain	_____
Croatia	_____	Italy	2	Sweden	4
Czech Republic	_____	Latvia	_____	Switzerland	2
Denmark	3	Lithuania	_____	Ukraine	_____
Estonia	_____	Netherlands	3	Yugoslavia	_____
Finland	1	Norway	2	USA	2
France	36	Poland	1	Total	_____
Georgia	_____	Portugal	4		

EUROMECH 360

MECHANICS OF SANDWICH STRUCTURES

Chairmen: A. Vautrin, Saint-Etienne, France; A. Torres Marques, Porto, Portugal

scientific report

The Euromech Colloquium 360 held on May 13th. -15th., 1997 has been organised by the Ecole des Mines de Saint-Etienne, France. The scope of the Colloquium encompassed the modelling, numerical simulation and experimental identification of sandwich constructions mechanical behaviour.

The Colloquium addressed the latest advances in modelling of sandwich structures properties since the large variety of core and face materials, related to major improvements in manufacturing processes, give new prospects to design and manufacture sandwich structures with complex shapes and enhanced performances. Interest in sandwiches is permanently growing, especially for transportation structures, and improved testing and modelling approaches should be set up to lead to better founded guidelines for designing.

The major topics covered by the papers presented at the colloquium are:

- Sandwich structure modelling, including analytical and FE approaches (17 papers),
- Mechanical testing of sandwiches and core materials (9 papers)
- Analysis and testing of joints and inserts (3 papers),
- Impact and crash behaviour (7 papers),
- Dynamic properties of sandwiches and core materials (6 papers),
- Industrial applications, design and manufacturing (5 papers).

Only a few papers addressed specific design approaches, including joining and manufacturing, local and global panel or shell stability. Optimisation of sandwich constructions has only been discussed during the final round table.

The scientific committee received 70 abstracts, among which 8 have not been accepted for presentation. Still, 10 other papers have been cancelled, therefore 52 papers have been presented : 5 keynote lectures, delivered by leading scientists and introducing the oral sessions, 28 oral presentations and 19 posters. 74 participants attended the Colloquium, of which 33 were French scientists. Participants have been provided with a scientific package that comprised the Colloquium programme, the *extended abstracts* of the presentations (a two or three page abstract per paper provided by the authors after the acceptation) and the list of session chairmen. The list of participants has been released at the end of the Colloquium. *Extended papers* reviewed by the scientific committee will be published in 1998 by KLUWER Academic Publishers.

The keynote lectures highlighted different theoretical or applied acute problems and served as introductions to the specialised oral sessions. They focused on the classification of sandwich structures (Prof. H.G. Allen, University of Southampton, UK), the development of advanced sandwich structures for naval vessels (Prof. K.A. Olsson et al., Royal Institute of technology of Stockholm, S), the damaged tolerance of aeronautical sandwich structures (Dr. Guedra-Degeorges et al., Aérospatiale, F), the numerical simulation of the crash behaviour of sandwich structures with fibre reinforced polymer-faces (Prof. M. Maier and Dr. S. Kerth, Institut für Verbundwerkstoffe, Kaiserslautern, D) and the numerical models and optimisation of sandwich structures (Dr. J. César de Sà et al., University of Porto, P).

The main conclusions from the conference debates are :

- Sandwich panels still remain complex structures whose behaviour depends on many materials and structural parameters. The characterisation of their mechanical properties should be based on hybrid identification approaches bringing together numerical modelling and testing.
- Experimental procedures to characterise the behaviour of sandwich panels under complex loading should be set up. Standard tests cannot be used as characterisation tests. In particular, reliable analyses of the buckling behaviour require better controlled boundary conditions and advanced field metrology (optical techniques).
- Development of models taking in account the microstructure of the core materials is necessary. The specific properties of sandwiches due to the special shape of the core cells should be predicted to assist the engineer when designing the sandwich components. Approaches based on homogenisation methods have to be supported.
- The actual difficulty to find out properties of core materials that could be used for structural design is emphasised. Development of advanced experimental approaches is required to identify the dynamic (energy absorption) properties and ultimate strengths of foams over broad frequency ranges and under various environmental conditions.
- The effects of environmental conditions on the sandwich structure behaviour and durability should be considered to achieve optimising load bearing structures. There is a present lack of data on time-temperature-moisture effects on composite materials and polymers which restricts the application in structure design.
- Local buckling of beams and panels should be more investigated both through numerical simulations and experimental testing. Special attention is to be paid to boundary conditions modelling and experimental achievement. Defects have to be considered to predict buckling loads and post-buckling behaviour.
- Several papers concentrate on the design of sandwich joints and inserts. Insert design is regarded as a topic of prime importance for crashworthiness of transportation structures; research on joints and inserts analysis should be stimulated to build up design guidelines.
- The closer link between sandwich structures and processes has been emphasised and innovative structures, based on new types of reinforcement, are strongly bound to the capability to model the manufacturing process. The integration of new functions depends on the progress of processes and the available numerical tools to predict the final properties.
- Many special finite elements have been developed to predict sandwich deflection (large displacements...) and assess transverse stresses. There is an obvious need to

check and compare the performances of these tools and determine their ranges of practical interest. Reliable analytical and numerical reference solutions are essential to compare the efficiency of numerical tools and particular in regions submitted to stress gradients.

- Analytical solutions are established under better controlled assumptions than numerical ones and it has been decided to undertake a first round-robin test to compare different numerical and analytical approaches to analyse the bending of sandwich beams. Results should be released in an international scientific journal on structure analysis.