

MECHANICS OF SANDWICH STRUCTURES

Mechanics of Sandwich Structures

Proceedings of the EUROMECH 360 Colloquium
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EUROPEAN MECHANICS COLLOQUIUM 360

MECHANICS OF SANDWICH STRUCTURES

MODELLING

NUMERICAL SIMULATION

EXPERIMENTAL IDENTIFICATION

SAINT-ÉTIENNE, 13 - 15 MAY 1997

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INTRODUCTION

The main advantages of sandwiches as structural components are now well-known and well-established. Due to the progress in polymer science and engineering and advances in manufacturing processes, sandwich structures can blend various functional and structural properties and therefore lead to highly innovating systems. The current difficulty to overcome is to provide designers with proper methodologies and tools that could enable them to design improved sandwich structures. Such dedicated design tools should be efficient, reliable, flexible and user-friendly. They should be based on advanced knowledge of sandwich behaviour at global and local scales. Such approach relies on our capability to test, identify, control and model structure performances.

The impressive variety of core and face materials and the rapid developments in forming processes give new opportunities to design components which have more complex shapes and higher integrated functional and structural properties. Interest in sandwiches is permanently growing in industry and refined testing and modelling approaches should be encouraged to set up relevant guidelines to design reliable advanced structures.

The European Society for Mechanics sponsored the EUROMECH 360 Colloquium on the 'Mechanics of Sandwich Structures' in Saint-Étienne, France, on 13 - 15 May 1997. The main purpose of EUROMECH 360 was to go into the most recent progresses in sandwich analysis and design, including mechanical modelling and testing. It was expected that the Colloquium should contribute to define new research directions to support development of advanced applications in strategic industrial sectors such as ground transportations or building and civil engineering.

5 keynote lectures, 28 oral presentations and 19 posters have been selected by the scientific committee for presentation at EUROMECH 360. 74 participants from 19 different countries attended the sessions among which 33 were French scientists. The extended abstracts of the papers (a two - three page abstract per paper) have been provided to the participants.

The keynote lectures have highlighted different theoretical or applied problems. They have served as introductions to the specialized oral sessions. They focused on the classification of sandwich structures (Prof. H.G. Allen, University of Southampton, U.K.), 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, Kaiserlautern, D) and the numerical models and optimisation of sandwich structures (Dr. J. César de Sà et al., University of Porto, P).

The main themes covered by the Colloquium are:

- * Modelling of sandwich structure behaviour;
- * Dynamic properties of sandwich structures;
- * Identification of sandwich and core material mechanical properties;
- * Industrial applications and manufacturing.

A few papers tackled more specific topics such as sandwich joining and manufacturing, or local and global sandwich panel stability.

The present Proceedings comprise 49 extended papers which have been reviewed by the scientific committee of EUROMECH 360. Two experts have been in charge of the review of each paper after the Colloquium took place. Many changes have been suggested by the reviewers and introduced by the authors before publication.

The papers have been arranged in seven thematic sections. Most of the papers could belong to several sections, therefore the classification here should be considered as a simple way to help the reader to retrieve any scientific information easily.

- I- Finite Element Modelling
- II- Modelling
- III Buckling and singularities
- IV - Dynamic and impact behaviour
- V - Experimental testing and control
- VI - Sandwich and constituents properties
- VII- Sandwich design

The main conclusions coming up from the round table that concluded the Colloquium are summarized below :

- * there is an actual difficulty to find out complete sets of *core material* properties suited to structure design; development of rational testing routes is absolutely necessary to provide reliable static and dynamic properties of foams and honeycombs to be used for designing;
- * new testing methodologies to get comprehensive view of sandwich panel behaviour under service loadings, including environmental effects, should be strongly encouraged; in particular there is a specific demand for panel impact strength characterization and prediction;
- * particular advances in panel local buckling analysis are needed when large structures are in view; it requires progress in numerical modelling and testing, improvements in boundary condition control and strain field measurements are necessary;
- * advanced mechanical modelling of joints and inserts is required; new approaches to optimize the joining design should be appreciated when dynamic or impact loadings are likely to occur, and safety conditions have to be guaranteed such as in transportation applications;
- * new materials for sandwich skins and cores, such as anisotropic polymer composites or knitted materials, are highly promising, improved physical

- and mechanical characterization and modelling are to be supported to point out the specific advantages they enable to achieve, including the forming process and joining technics;
- * improved methodologies to check and compare finite element efficiency have to be set up; a great deal of sandwich dedicated finite elements have been developed in the past few years, however their validity ranges have not been determined and their advantages over often existing finite elements have not been pointed out; two routes should be introduced :
 - * comparisons between finite elements and analytical solutions, developement of new analytical solutions is still relevant since they usually give better insight into the assumptions that are made;
 - * comparisons between finite elements solutions and experimental results, special attention has to be paid to the boundary conditions and strain measurements when panels are tested;
 - * computer aided sandwich design tools should be supported; in particular, rational materials selection methods are needed since sandwich panels are supposed to integrate different functions and cut down production costs;

A benchmarking test to compare the reliability and efficiency of different sandwich beam analyses has been set up. 10 European research groups are involved in the process which intends to calculate the stress and strain fields in beams subjected to four point bending. Special attention is paid to the stress concentration near the loading points and between skin and core. Both linear and non linear finite element calculations are performed and compared. Comparisons with analytical analyses are carried out as well. The results of the benchmarking test will be published and extensions to other geometries and loading cases will be contemplated.

This volume provides the reader with a current view of methods of mechanical modelling, materials and structures testing approaches and overall conclusions dealing with the mechanical properties of the sandwiches, including impact performances and instabilities. It can be valuable to engineers and scientists in industry, as well as to professors and students at universities, to keep them up to date in this rapidly growing field.

ALAIN VAUTRIN
Saint-Étienne, November 18, 1997.

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ALAIN VAUTRIN

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