PROJECT

BOJCAS

Bolted Joints in Composite Aircraft Structures

**Funding:** European (5th RTD Framework Programme)
**Duration:** Feb 2000 - May 2003
**Status:** Complete with results

Background & policy context:
Improved methods for designing efficient composite bolted joints are required by the aircraft industry since the introduction of composites into the primary structure of large aircraft is one of the chief means being considered for reducing weight. This will lead to more heavily loaded composite bolted joints than ever before, so in the interests of competitiveness and safety, optimal design methods are needed.

Current methods date from work primarily carried out in the USA in the 70s and 80s, and are largely empirical in nature. With new materials, and more heavily loaded configurations, the validity of empirical methods becomes less certain.

This will inevitably lead to excessively conservative (overweight) joint designs.

In fact, due to the safety critical nature of joints, the design of the overall structure tends to follow from, and be significantly limited by, the design of the joint. Thus inefficient joining technology can seriously erode any potential benefits to be gained from using composites.

Objectives:
The principal objective of BOJCAS was to develop advanced design methods for bolted joints in composite aircraft structures.

The methods developed in BOJCAS incorporate recent developments in computational mechanics and are more adaptable to new materials and configurations. This gives them the potential to significantly reduce testing and hence time/cost of development, as well as aircraft weight with consequent increase in efficiency. This should also help to ensure continued safety.

Methodology:
The project was divided into two strands directed towards two major goals:

- global design methods for preliminary design and
- detailed design methods for final design of critical joints.

Each strand contained major testing and analysis components.
At the global level, a series of benchmark structures representative of primary, multi-fastener joint configurations, were defined and tested. The structures addressed key issues such as composite-to-metal joints (for potential composite wings), bolted repairs, and joint optimisation. Global design techniques were developed based on two-dimensional finite element methods, and validated on the benchmarks.

At the detailed level, an extensive programme of specimen tests supported the development of detailed design methods, based on three-dimensional finite element techniques. These account for non-uniform through-thickness stress distributions, which are particularly important for primary joints with thick laminates. Progressive damage models and new fatigue-based failure criteria were developed, and automated model-building tools were created.

Bridging the two strands were methods to automatically couple global and detailed methods. Tests were extensively instrumented and detailed fractographic failure analysis was performed. The tests and analyses formed the basis for design guidelines on key issues.

**Related Projects:**

- TANGO - Technology Application to the Near-Term Business Goals and Objectives of the Aerospace Industry
- EDAVCOS - Efficient Design and Verification of Composite Structures
- APRICOS - Advanced Primary Composite Structures
- CRAHVI - Crashworthiness of Aircraft for High Velocity Impact

**Parent Programmes:**

FP5-GROWTH KA4 (AERONAUTICS) - New Perspectives in Aeronautics

**Institute type:** Public institution

**Institute name:** European Commission, Directorate-General for Research (DG Research)

**Funding type:** Public (EU)

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**Key Results:**

The main results from BOJCAS were:

- Global design methods, for preliminary design of complex, multi-fastener joints
Detailed design methods for final design of critical joints

- Methods to couple global and detailed design methods
- Design guidelines for primary composite bolted joints based on analyses and tests
- Basic research information on the behaviour of composite bolted joints.

For instance:

Two different global design methods representing the fastener/hole interaction in a simple yet physically realistic way were developed. Global-local coupling methods were implemented into three different FE codes used in the industry. Two software tools for automated creation of three-dimensional finite element models of bolted joints were developed, which enable this complex task to be performed quickly and reliably. Progressive damage analysis methods were developed and applied to predict failure of composite bolted joints loaded quasi-statically and in fatigue. Finally a tool for optimisation and damage tolerance studies of complex joints involving large numbers of fasteners was developed and implemented in a multi-processing environment. All the developed tools were validated with an extensive experimental test programme involving a large number of joint parameters and joints of varying complexity. Significant fundamental information was generated from this test programme, leading to several publications in journals and conferences.

Policy implications

BOJCAS generated a significant amount of new tools for design and analysis of composite bolted joints, which are expected to be assimilated into the design process in the European aerospace industry. It is recommended that the tools be developed further in future research actions. BOJCAS also generated much fundamental information on composite bolted joint behaviour and raised issues concerning testing standards and design processes that need further investigation.

Air

Key Findings

No results directly relevant to this theme. However, please note that some findings relevant to the project’s key theme (Vehicle Technology) are generically applicable.

Policy Implications

No policy implications directly relevant to this theme. However, please note that some policy implications relevant to the project’s key theme (Vehicle Technology) are generically applicable.

Efficiency

Key Findings

No results directly relevant to this theme. However, please note that some findings relevant to the project’s key theme (Vehicle Technology) are generically applicable.

STRIA Roadmaps: Vehicle design and manufacturing
Transport mode: Air transport
Transport sectors: Passenger transport, Freight transport
Transport policies: Safety/Security
Geo-spatial type: Other