

CRASHWORTHINESS OF VEHICLE COMPOSITE SANDWICH STRUCTURES

P. C. Neves¹, A. A. Fernandes^{1,2}, A. J. M. Ferreira²

¹ IDMEC - Institute of Mechanical Engineering, R. Dr. Roberto Frias, Porto, Portugal

² Department of Mechanical Engineering, U.Porto - FEUP, R. Dr. Roberto Frias, Porto, Portugal

Introduction

Increasing awareness by the public opinion about environmental issues, energy and material conservation at all stages of product life (from raw materials to disposal/recycling) is putting the industry in general and the transport industry in particular under increased pressure to reduce CO₂ emissions and save energy. Environmental protection and safety will be increasingly influenced by legislation.

The European transport industry is estimated to generate 22% of the carbon dioxide emission. As the car population is expected to grow 40% by the year 2010 new tough targets for reducing emissions by 30% in 2010 are being set by the EU, against the state of the art technologies of 1995. It is generally agreed by the industry that reductions of this size will require a change in current technologies.

Multimaterial technology (sandwich and/or hybrid materials) is becoming increasingly important in new vehicle design. It offers significant opportunities for enhancement of product performance in terms of strength, stiffness and crashworthiness, combined with weight reduction and space saving. Its use still lags far behind steel in the production of cars, buses, coaches and rail and marine applications. Public service vehicles (buses and coaches) are regarded as primary targets for application of sandwich construction and multimaterials.

Public service vehicles (PSV) play a major role in the transportation industry of both industrialized and developing countries. Although the share of passenger transportation in PSV is relatively small compared to private cars (10% for bus, 5% for train), environmental and energy conservation constraints will lead to an increased demand of PSV, mainly in cases with limited access (like city centers). As travel by car has increased at a steady rate, of 2% per year, whereas bus increased 0.9% and train 0.4%, the EU White Paper on European transport Policy for 2010 establishes, as main goal, a shifting of balance from car to public transport, through the development of high quality and safe transport, eliminating the root causes of pollution – the use of

individual transportation. The project was focused on the development of a novel technology to manufacture bus/coach bodies using load carrying sandwich multimaterial panels that have to meet tough design requirements, such as: high static and dynamic performance, high flexural and torsional stiffness, adequate acoustics, crashworthiness, higher safety for passengers, reduced harm to pedestrians in case of accident, fire safety, corrosion resistance, easy repair characteristics and reduced assembly time.

Main overall objectives of the project

The main overall objectives of the project were:

- Solving the problem of reducing weight and production costs of land transport vehicles through the development of a technology of modular bus/coach construction, using “all composite” multi-material load carrying sandwich panels instead of a steel/aluminium space-frame lined with sheets of different materials (metallic or non-metallic).
- Devise design methodologies that reduce production lead time through reduction of number of components, functional integration, and allowance for dismantling, easy repair and recycling.
- Developing high quality urban transport
- Contribute to the shifting of balance between modes of transport.
- Contribute to improve road safety.
- Contribute to improve quality in the road transport sector.

The main goals of the project were the reduction of weight and production costs through:

- Development of a new concept “all composite sandwich material” for the production of structurally resistant modular panels for the construction of “Body in White” structures, reinforced with fibre reinforced pultruded sections (FRP) sections.
- Development of a new concept vehicle architecture where “load carrying modular sandwich panels” are used instead of the traditional space-frame structure (in steel or aluminium) lined with sheets of steel or

aluminium. The use of sandwich construction and composite materials means that a higher functional integration will be achieved through the incorporation, in the structure, at manufacturing stage of several functions, allowing more efficient space usage and cost efficient manufacturing.

Results and Discussion

The main technical achievements are summarised below:

- Design, manufacture and validation of a sandwich material concept with high stiffness and energy absorption suitable for surface transport vehicle.
- Generation of new concept vehicle architecture, using systematic product development methodologies and Integrated Product Policy for a more environment friendly vehicle.
- Develop a new manufacturing technology for the production of large panels with functional integration.



Fig. 1 – Rendering and mock-up

Components were manufactured and tested. Particular attention was devoted to the design and production of the pultruded section. Static and fatigue tests on materials and components were performed.

A numerical model was developed for composite-composite bonded joints. The activities were developed with the active collaboration of all partners, both during specific work-package meetings, exchanges through email and during the Steering Committee meetings.

Several pillar rings were built and test in conditions corresponding to annex 8 of R66.

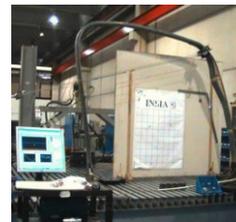


Fig. 2 – Quasi-static tests

The prototype cell was then assembled and tested in real roll-over.

Residual (survival) space was preserved during the test. Figure 3 shows the most critical moment on the right side. Thus, the roll-over test validated the proposed new concept of bus body, as far as crashworthiness is concerned. Flexural and torsional stiffness were also demonstrated to be at least equal to equivalent steel bodies.



Fig. 3 Roll-over test result

Conclusions

The Litebus project was concluded on 31st December 2009. The prototype of a bus body-in-white section constructed with sandwich panels was produced and successfully tested in roll-over according to the UNECE's Regulation No. 66.