Guest Editorial

This special issue of the International Journal of Adhesion and Adhesives (IJAA) contains selected papers presented at the Special Session on 'Adhesive Bonding' held at the 4th International Conference on Advanced Computational Engineering and Experimenting (ACE-X 2010) meeting. ACE-X 2010 was chaired by both of us and Prof. H Altenbach and was held in Paris, France, during July 8–9, 2010. The goal of the conference was to provide a unique opportunity to exchange information, present the latest results as well as to discuss issues relevant to engineering mechanics research today. The importance of science and technology of adhesion in engineering applications spurred the chairman of the ACE-X 2010 meeting to include a special session dedicated to this subject, organised by one of us (LFMdS) and Prof. Jean-Yves Cognard. Approximately 70 papers were presented by researchers from more than 20 countries in the "Adhesive Bonding" Special Session. The organisers wish to thank the authors and delegates for their participation and cooperation, which made this Special Session possible. In order to disseminate the work presented in the Special Session on 'Adhesive Bonding', selected papers were prepared, which resulted in the present Special Issue. A wide range of topics were covered and many excellent papers were submitted. The criterion adopted for inclusion in this Special Issue was that these papers should be related to 'Joint Design'. Analytical and numerical techniques for stress determination in adhesive joints are presented. Failure criteria based on the traditional continuum mechanics are used as well as more sophisticated methods such as fracture mechanics and damage mechanics are used. When using any of these criteria it is important to know beforehand what are the true properties of the adhesive and how they can be improved and this aspect is also covered here. Finally, some practical applications are given. The correct determination of the adhesive properties is a crucial point in 'Joint Design'. A proper joint strength prediction can be made only if the true adhesive properties are determined. This question is dealt with in the first two papers. Adhesives used in structural high temperature aerospace applications must operate in extreme environments. As is known, adhesive strength generally shows temperature dependence. Similarly, the fracture toughness is expected to show temperature dependence. Banea et al. used the Double Cantilever Beam (DCB) test to evaluate the effect of the temperature on the adhesive mode I fracture toughness of a high temperature epoxy adhesive. Cohesive zone models, in which the failure behaviour is expressed by a bilinear traction–separation law, were used to define the adhesive behaviour. Fernandez et al. evaluated the performance of different data reduction schemes to obtain the energy release rate (GI) in the Fatigue Crack Growth Rate (FCG) using DCB specimens. The authors propose an alternative data reduction scheme based on specimen compliance and crack equivalent concept to determine the Paris law. The third paper on adhesive properties by Sancaktar and Kuznicki examines epoxy-clay nanocomposites. The most noticeable improvements in mechanical properties were found to be maximum stress, elastic modulus and yield stress. Increased toughness and stress whitening at 1% by weight nanoclay loading revealed that the clay can act as a shear-yielding toughening agent in this epoxy system. The stress analysis is a major step in 'Joint design'. This is obtained either by analytical models or by numerical techniques. Two papers propose design procedures based on analytical models. Goglio and Rossetto propose an analytical model for double lap joints, which accounts for bending in the external adherends and axial stiffness imbalance. Several cases of adherend to adhesive elastic modulus ratio, thickness and overlap length are considered. It is found that the analytical solutions give acceptable results when the elastic modulus of the adhesive is much lower than that of the adherends. In the paper of Sato, the residual stresses in an adhesive layer between adherends with different curvatures were investigated analytically assuming the adherends as linear elastic beams and the adhesive layer as linear viscoelastic springs. A governing equation giving the time variation of the adhesive deformation caused by the viscoelastic deformation is presented. The equation is an ordinary differential equation of 4th order including a convolution equation of the creep compliance or the relaxation function equivalent to the linear viscoelastic characteristics of the adhesive. Papers using the finite element (FE) method for the stress analysis are also presented. Liao and Sawa analysed the stress wave propagations and stress distributions in epoxy-steel composite cylinders in which the outside surface of a solid cylinder (steel) is adhered to the inside surface of a hollow cylinder (epoxy) subjected to impact push-off loads with small strain rate in elastic and elasto-plastic deformation ranges. The strength of the composite cylinders increases as the rigidity of the solid cylinder increases, the diameter and the height of the solid cylinder decrease. In addition, it is observed that the characteristics of the joints subjected to impact loads are opposite to those of the joints subjected to static push-off loads. Ribeiro et al. propose a numerical strategy based on a FE method in order to model the stress distribution in single-lap adhesive joints with unidirectional carbon-fibre-reinforced epoxy composites. Joints with different types of defects in the lap region were modelled with both two-dimensional and three-dimensional FEs. The effect of defects in the joints was adequately modelled, and the proposed methodology can be used to accurately assess the integrity of the joints. Castagnetti et al. assess the accuracy and applicability of an efficient FE computational method for the prediction of the post-elastic response of large and complex bonded structures. The method is based on standard modelling tools, describes the adherends by semi-structural elements (plates or shells) and the adhesive by means of a single layer of cohesive elements. A square thin-walled beam is considered, made of two different portions butt joined by overlapping thin plates on each side. The comparison with the experimental data shows a good accuracy of the proposed method in terms of structural stiffness, maximum load and post-elastic behaviour up to the collapse of the structure. Cohesive damage models give good predictions provided the traction–separation law is properly determined. Khalili and Ghaznavi studied the effects of fillet geometry and core material of sandwich panels on the performance of T-joints. Cohesive zone elements were used to model the adhesive. The failure load predicted by the numerical analysis was within 5% of the experimental results. Kim et al. used the superimposed finite element method to generate automatically cohesive elements. The total mesh generation time is reduced and the element quality is improved. The proposed method is applied to several examples. Cohesive zone models have already proved to be an effective tool in modelling damage growth, surpassing a few limitations of the aforementioned techniques. Despite this fact, they still suffer from the restriction of damage growth only at predefined growth paths. The Extended Finite Element Method (XFEM) is a recent improvement of the FE method, developed to allow the growth of discontinuities within bulk solids along an arbitrary path, by enriching degrees of freedom with special displacement functions, thus overcoming the main restriction of cohesive zone models. These two techniques were tested by Campilho et al. to simulate adhesively bonded single- and double-lap joints. The comparative evaluation of the two methods showed their capabilities and/or limitations for this specific purpose. The papers of Engerer and Sancaktar and Pinto et al. are more experimental in nature and assess the influence of defects on the joint strength. Engerer and Sancaktar studied the effects of the presence and size of gaps in the band single-lap joint. Two types of adhesives, a deformable, acrylic tape and an epoxy putty, were used as adhesives. For both adhesive types the introduction of the gap had a moderate negative effect on the load carrying characteristics of the joint, but the joints utilising the epoxy putty maintained joint strength as the gap size was increased to 9.53 mm (38% gap), while the highly deformable acrylic tape case displayed a constant decline maintaining constant ultimate shear stress values. Pinto et al. analysed the effect of hole drilling at the overlap on the strength of single-lap joints. Tests were made with two adhesives (a brittle and a ductile one) varying the adherend thickness and the number, layout and diameter of the holes. Experimental testing showed that the joints strength never increases from the un-modified condition, showing a varying degree of weakening, depending on the selected adhesive and hole drilling configuration. The preparation of this Special Issue has been an interesting experience for the guest editors. The review process gave a deeper insight into the various aspects of joint design and the opportunity to discuss in detail the articles directly with the authors. We would like to thank the authors for their patience with the process and the reviewers for providing critical evaluations of these articles. Finally, we especially thank Prof. Bob Adams, Joint Editor-in-Chief of IJAA, who made this Special Issue possible.