Comparative study of laminated glass beams response

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Studio comparativo del comportamento di travi in vetro stratificato

ABSTRACT

Failure of laminated glass units is characterized by the growth and propagation of interfaces that can arise in unpredictable location of the layers. In the paper a comparison between theoretical and numerical predictions of the response of laminated glass beams is presented. Specifically the results in term of stress and peak load by the theoretical procedure in [1] have been compared with the numerical predictions obtained by means a Finite Element discretization, both in the case of linear elasticity. Experimental results are considered too.

Moreover a general model considering damaging embedded interfaces in the context of the SDA has been considered [2, 3]. The model is obtained in a consistent thermodynamic framework from a generalized variational principle incorporating internal variables, thus allowing also for nonlinear continua. The principle starts from basic energetic considerations. The strain field is decomposed into a compatible and an enhanced term. The numerical implementation of the algorithm is based on the formal analogy between the equations of the enriched continuum and the theory of classical plasticity, following recently developed strategies [4], [5],[6]. The growth or the activation of interfaces is ruled by specific activation functions. In this way it is obtained a structure of the numerical algorithm that allows the use of the procedure inside classical F.E. codes for the solution of the equilibrium problem of elastic-plastic solids.

The model has been specialized for the application to laminated glass beams, introducing cohesive fracture-like criteria, and applied to investigate the flexural behaviour of a simply supported laminated glass beam and the growth and propagation of interfaces inside the glass layers and across the polymeric interlayer. The fracture path due to a static transversal load has been compared with experimental evidence from a standard three point bending test. The predictions about the initiation of cracks inside the layers are also compared with the analytical and numerical results previously obtained.

Some remarks about the identification of the constitutive parameters defining the cohesive fracture-like criterion ruling the interface behaviour in the SDA model close the paper. An attempt has been made in estimating the fracture energy from the molecular work of adhesion among the layers by means molecular dynamics simulations. From the results, we can assess that these techniques are a reliable and useful tool to predict the interfacial properties of these polymeric composites [7, 8, 9].

References

[1] M. Z. Aşik and S. Tezcan. A mathematical model for the behavior of laminated glass beams. *Computers and Structures*, **83**, 1742–1753, 2005.

[2] L. Contrafatto. Application of the strong discontinuities approach for the analysis of laminated glass units. In *Proceedings of 2nd South-East European Conference on Computational Mechanics - SEECCM 2009*, V. Papadopoulos M. Papadrakakis, M. Kojic, editor, Rhodes, Greece, 2009. full text on CD ROM.

[3] L. Contrafatto and M Cuomo. Finite element implementation of an enhanced strong discontinuities approach formulation vs. smeared crack models. In *Proceedings of IV European Conference on Computational Mechanics - WCCM 2010*, Paris, France, 2010. full text on CD ROM.

[4] J. Mosler. On the modelling of highly localized deformations induced by material failure: the strong discontinuity approach. *Archives of Computational Methods in Engineering*, **11**, 389–446, 2004.

[5] J. Mosler and O.T. Bruhns. A 3D anisotropic elastoplastic-damage model using discontinuos displacement fields. *Internat. J. Numer. Methods Engrg.*, **60**, 923–948, 2004.

[6] J. Mosler. A novel algorithmic framework for the numerical implementation of locally embedded strong discontinuities. *Comp. Meth. App. Mech. Eng.*, **194**, 4731–4757, 2005.

[7] A. Caroli, R. Frassine and G. Manni. Resistenza a frattura di adesivi strutturali per applicazioni numeriche. In *Proceedings XIX IGF Conference*, Milan, Italy, 2007. full text on CD ROM.

[8] E. H. Andrews and A. J. Kinloch. Mechanics of adhesive failure. In *Proceedings Roy. Soc.*, volume 332, 401–414, London, GB, 1973.

[9] f. Awaja, M. Gilbert, G. Kelly, B. Fox and P. J. Pigram. Adhesion of polymers. *Polym. Sci*, **34**, 948–968, 2009.