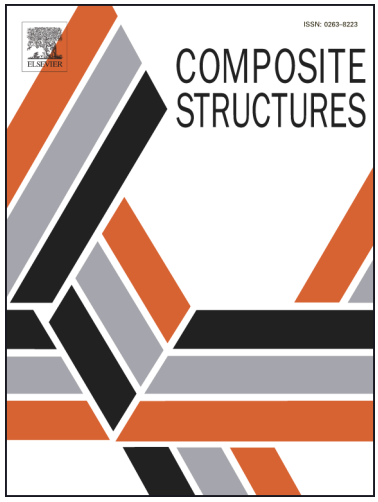

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Thermo-mechanical modelling of laminated glass with the use of two-dimensional in-plane mesh

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Abstract

The three-dimensional (3D) numerical modelling of laminated glass (LG) plate subjected to coupled thermomechanical loading is in the scope of this paper. The method called FEM23 is applied, in which a 2D in-plane mesh is used, however full 3D results are obtained. In any LG plate glass panes are bonded by very thin polymer films. This layered structure consists of subsequent thick and thin layers of glass and polymer, respectively. Additionally, the thermal and mechanical properties of the glass and the bonding polymer are significantly different. FEM23 is suitable for analyses of such kind of structure. The full 3D results of the coupled problem are obtained following special FEM23 postprocessing. FEM23 is a relatively simple, robust and effective method and 3D thermo-mechanical results obtained are correct for both stationary and non-stationary heat transport. The accuracy of the method has been examined with the use of solutions obtained from the ABAQUS system. The examples presented in the article include two-, three- and four-paned LG plates.

Keywords: laminated glass, postprocessing, Finite Element Method, bending plate, coupled problem

1. Introduction

The subject matter of this paper is the thermo-mechanical numerical analysis of laminated plates, with special focus on laminated glass (LG) plates. The analysis presented here is a full three-dimensional (3D) analysis done with the use of the two-dimensional (2D) finite element method (FEM), which gave the method applied here its name – FEM23. FEM23 has already been presented in two previously published papers [1, 2], where it was applied to both thermal and mechanical problems. In this paper, FEM23 is extended so that could also be applied to a complex thermo-mechanical numerical analysis dealing with the coupled problem of linear elasticity and heat transport in a laminated plate. The mechanical and thermal components have been coupled together with the use of the thermal expansion coefficient, which means that temperature affects the strain field, but there is no feedback.

This paper uses FEM23 for numerical analysis of the thermo-mechanical problem in a laminated glass structure. An LG plate consists of two or more glass panes which are bonded by thin polymer films. Thus, an LG plate is a multi-layered structure composed of relatively thick panes of glass (usually 3–12 mm) separated by a thin polymer binding layer (usually 0.38–1.52 mm). The polymer films are most commonly made of PVB (polyvinyl butyral). However, other polymers, such as EVA (ethyl vinyl acetate) or SentryGlas ionoplast polymers, are also

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