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The flexural performance of laminated glass, a composite of two or more glass plies bonded together by polymeric interlayers, depends upon shear coupling between the glass components through the polymer. This effect is usually taken into account, in the design practice, through the definition of the *effective thickness*, i.e., the thickness of a monolith with equivalent bending properties in terms of stress and deflection. The traditional formulas *à la* Bennison–Wölfel are accurate only when the deformed bending shape of the plate is cylindrical and the plate response is similar to that of a beam under uniformly distributed load. Here, assuming approximating shape function for the deformation of laminated plates variously constrained at the edges, minimization of the corresponding strain energy furnishes new simple expressions for the effective thickness, which can be readily used in the design. Comparisons with accurate numerical simulations confirm the accuracy of the proposed simple method for laminated plates.

1. Introduction

Laminated glass is a sandwich structure where two or more glass plies are bonded together by thin polymeric interlayers with a process at high temperature and pressure in autoclave. Because of the shear deformability of the polymer, there is not a perfectly coupling between any two consecutive glass plies [Behr et al. 1993], and the degree of coupling depends upon the shear stiffness of the polymeric interlayer [Hooper 1973]. Consequently, the flexural response is somehow intermediate between the two borderline cases [Norville et al. 1998] of *layered limit*, i.e., frictionless relative sliding of the plies, and *monolithic limit*, i.e., perfect bonding of the plies. This problem has close similarities with the case of composite beams with partial interaction. The most classical contribution, conceived of for a concrete slab and a steel beam bonded by shear connectors, is associated with the name of Newmark et al. [1951], who considered a linear and continuous relationship between the relative interface slip and the corresponding shear stress. More recently Murakami [1984] introduced the usual hypotheses of Timoshenko beam to model the interlayer in the analysis of composite beams. In a recent paper, Xu and Wu [2007] presented a very comprehensive approach for static, dynamic and buckling behavior of composite beams with partial interaction, accounting for the influence of rotary inertia and shear deformation. Approximate formulations of this kind are particularly important for studying the problem of buckling of composite columns (e.g., [Le Grognec et al. 2012; Schnabl and Planinc 2011]), applicable to various materials, including lamellar wood [Cas et al. 2007].

Geometric nonlinearities are usually important because of the slenderness of the laminated panel [Aşik 2003], but are usually negligible when the loads are orthogonal to the panel surface and no in-plane forces are present. From an analytical point of view, it is often very difficult to obtain a closed-form solution for the strain and stress field in a laminated glass plate. An analytical approach has been recently proposed

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