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Lateral-Torsional Buckling of Laminated Structural Glass Beams. Experimental Study

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Abstract

This paper deals with experimental research of stability behaviour of laminated structural glass beams. The purpose of the research is the evaluation of lateral-torsional buckling resistance and actual behaviour of the beams due to absence of standards for design of glass load-bearing structures. The experimental research follows the previous one focusing on measuring of initial geometrical imperfections of glass members and experimental evaluation of flexural buckling resistance of structural glass columns.
Within the frame of the research 9 specimens were tested. All of them were of the same dimensions - length 2400 mm and width 280 mm but different thicknesses - 12, 16, 20 mm. All the beams were composed of two annealed glass panes bonded together by PVB foil. Beams were loaded by couple of forces symmetrically situated to the mid-span and supports complied with fork boundary conditions. Specimens were loaded by constantly increasing force up to failure. During testing lateral deflection, vertical deflection, angle of torsion and normal stresses at mid-span were measured. Maximum bending moment achieved during testing has been adopted as lateral-torsional buckling resistance. From these values were calculated characteristics and design values according to the EN 1990.
Experiment results were compared with lateral torsional buckling resistance calculated according to the buckling curves approach.

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Keywords: Lateral-torsional buckling; laminated glass; Southwell plot; experiment; critical moment; buckling curves

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1. Introduction

Glass members and structures are specific for their high slenderness. For this reason it is necessary to take into account stability problems within static designing. Design models developed for standard structural materials such as steel and timber cannot be directly used for design of glass structures because of some specific aspects of the glass (brittle fracture behaviour, time and temperature dependency of laminated glass etc.). Actually European design standards (Eurocodes) are in processing, designers may use draft versions of future final codes - prEN 16612 Glass in building – Determination of the load resistance of glass panes by calculation and testing or prEN 13474-1 Glass in building – Design of glass panes – Part 1: General basis of design. Static design of glass structures including stability problems of glass columns, beams and beam-columns is topic of work of Haldimann et al. [1], Belis et al. [3, 8] or Amadio and Bedon [2, 7]. This study follows previous author's research on stability problems of glass columns [9].

Nomenclature

ANG	annealed glass
VG	laminated glass (verbundglas)
PVB	polyvinyl butyral
W_{eff}	effective section modulus

Lateral-torsional buckling is loss of stability of bended member subjected to a rigid axis – see Fig. 1a. In the case of laminated glass member it is necessary to take into account an actual behaviour of the laminated cross section because of additional degree of freedom for bending and torsion of laminated glass – see Fig. 1b.

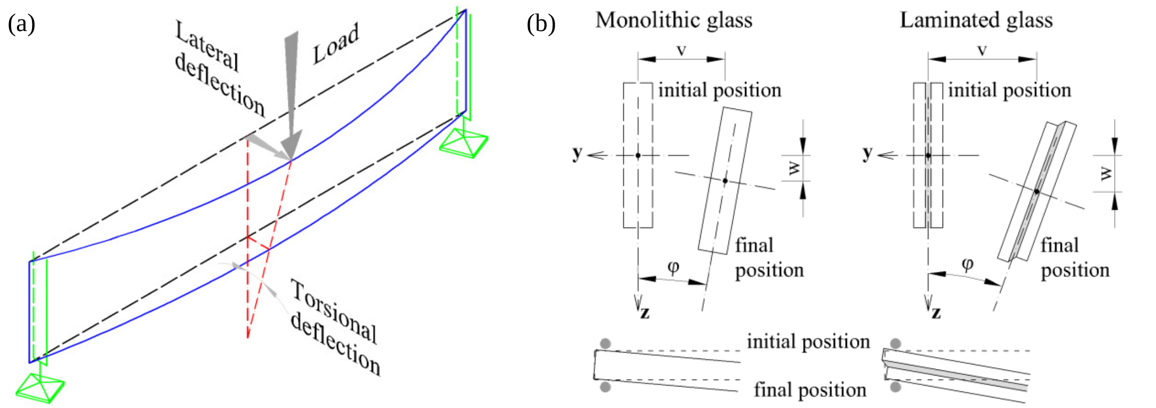

Fig. 1. Deformations of beam subjected to the lateral-torsional buckling: (a) Overall deformation; (b) additional deformation of laminated glass.

2. Experimental evaluation of lateral-torsional buckling resistance

2.1. Specimens

Within the frame of the research 9 specimens were tested. All of them were of the same geometry and composition (length 2400 mm, width 280 mm, laminated double glass made of annealed glass panes bonded together by PVB foil). Thicknesses of specimens were 12, 16 or 20 mm. The specimens are listed in Table 1.

Specimen geometry was chosen so that thin-walled (thin-walled in terms of structural mechanics, not steel structures) rod condition was fulfilled. Vlasov [4] defined a thin-walled rods by condition L : b : t = 100 : 10 : 1, where *L* is length of the rod, *b* is characteristic dimension of the cross section, and *t* is the wall thickness of the cross section.