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Compressive behaviour of laminated structural glass members

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ABSTRACT

Several experimental investigations in the past few years have highlighted the fact that the compressive strength of glass was significantly higher than its tensile strength, allowing new applications of glass in compression members. However, due to the high slenderness of structural glass elements made of thin glass panels, they tend to fail in a brittle manner. A substantial amount of fundamental research has been carried out in the past few years to investigate the stability behaviour of structural glass elements. However, although buckling of glass panels has been quite well studied, a very poor amount of research has been addressed to glass columns, which by contrast represent the most interesting case due to their direct application in buildings. In this paper, the results of ten compressive tests on glass panels and columns are presented and discussed. The main variables considered were slenderness of panels and the shape of the cross-section for columns. The results of six bending tests on monolithic and laminated glass panels are also shown, and the level of connection between the glass sheets was evaluated. A review of the theoretical background is provided and the results achievable with existing analytical models are compared.

1. Introduction

Glass started to be used in construction almost two thousand years ago after the invention of blown glass, which led to the production of thin transparent sheets to be utilized as windows. With this development, a new concept in architecture became possible. Nowadays, the concept of transparency has a greater and greater impact on architectural imagination. By combining glazing with new lightweight materials (aluminium, composite etc.) innovative solutions are achievable in architecture. The good amount of research done in the past decade has highlighted the fact that buckling is the major design issue due to the high slenderness of glass members. Several studies have focused on stability problems, such as flexural–torsional buckling [1–5], shear [6] or plate buckling [7]. The case of compressive elements was also studied in some works [8–13], always focusing on laminated glass panels. From an experimental point of view, Luible et al. [8,9] carried out an extended experimental programme, focusing on the most important aspects of buckling in glass panels. The authors discussed the most important parameters influencing buckling strength. The presence of many particularities (e.g. production tolerances, initial imperfections, interlayer properties and so on) caused difficulty in applying the well-known design methods available for the most common building materials (steel or timber) in the case of structural glass. Blaauwendraad [11] analysed three different expressions of the critical load available in the literature and ascertained that only the expressions proposed by Sattler et al. [12] matched the lower and upper bound values, corresponding, respectively, to the sum of the buckling strength of the glass sheets and to the buckling strength of a laminated panel with an infinite stiff foil, while the formulation of Zenkert [13] furnished an approximation of these. Blaauwendraad [11] also demonstrated that Allen's formula [14] did not provide correct upper and lower limits but conservative values for them.

The focus of this paper is to experimentally investigate the compressive behaviour of glass members, highlighting the second-order effects, analysing both panels and columns with two different shapes of the cross-section. Moreover, the results of bending tests on laminated and monolithic glass panes are shown and considerations are made on the level of connection between the glass sheets.

2. Experimental programme and specimens

The experimental programme provided bending and compressive tests on laminated glass members. Laminated glass was made with two 4 mm thick float glass layers bonded together with a polyvinyl butyral (PVB) layer with a thickness of 1 mm.

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