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Lateral Torsional Buckling (LTB) analysis of structural glass beams with discrete mechanical lateral restraints (LRs)

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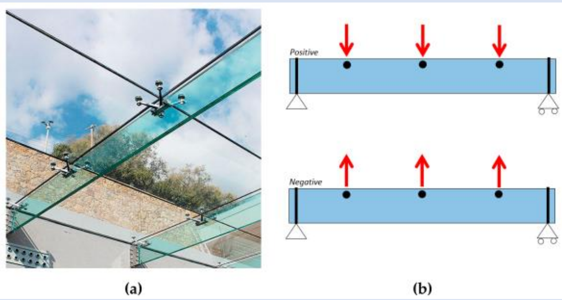
Abstract

Structural glass beams and fins are used as primary load-bearing members and bracing systems for roof or facade panels. The intrinsic features and vulnerability of the constituent materials, however, is known to require dedicated calculation methods for their safe structural design. Among other issues, glass fins are often characterized by high slenderness, and can be thus susceptible to premature Lateral Torsional Buckling (LTB) phenomena. While literature studies are available for the LTB analysis of laterally unrestrained (LU) glass elements, practical calculation methods and design recommendations are still weak for members that take advantage of discrete lateral restraints (LRs). This study focuses on the LTB assessment of LR glass beams with LR mechanical connectors, where relatively stiff point fixings are expected to locally restraint the brittle members, via glass holes.

Introduction

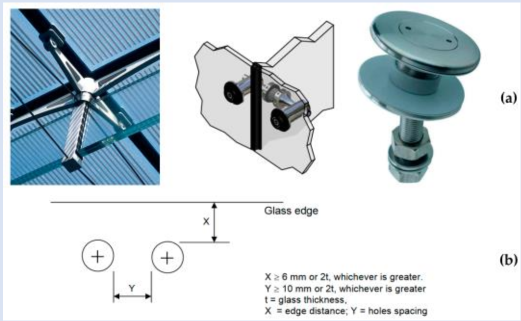
The first key step for the LTB design of a given member is represented, as usual, by the knowledge and prediction of its critical buckling load. As such, the primary goal of this study is to develop a practical model for the accurate calculation of the critical buckling moment M_{cr} of laminated glass members in LTB with LR point fixings. To this aim, selected configurations (Fig. 1) and mechanical connectors (Fig. 2) of technical interest are taken into account. A special role is assigned to refined Finite Element (FE) numerical models that are described in ABAQUS/Standard to reproduce the effects of a given number (n_b) of variably positioned and distributed (x_b, z_b) point fixings. Based on the post-processed FE parametric data, an empirical model for safe design purposes is thus developed from the classical LTB theories, and adapted LR glass members in LTB with variable features.

Materials & Methods



1. Typical example of (a) laterally restrained (LR) glass beams with discrete mechanical restraints and (b) schematic representation of the reference loading configurations for LR beams in LTB (associated, in the order, to positive or negative bending effects). Reproduced from [1] under the terms and conditions of CC BY license

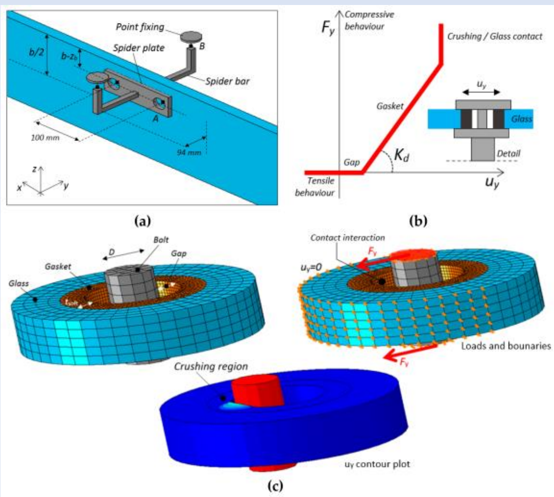
Major efforts are spent for the early detection of the LTB failure configuration of LR glass beams with mechanical point fixings. For the beam itself, the brittle collapse of glass must be prevented. In terms of mechanical point fixings, the challenge is to account for the actual restraint effect and local stiffness K_b (Fig. 3).



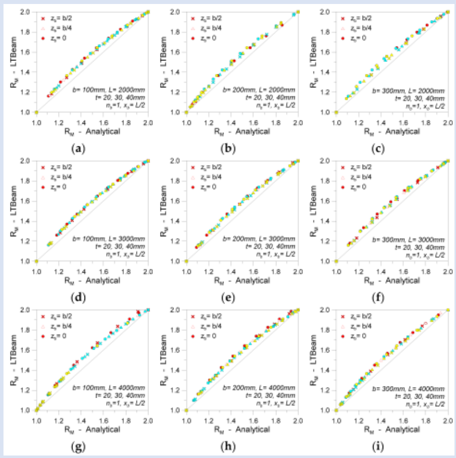
2. Detail of LR glass beams with discrete mechanical lateral restraints: (a) examples of point fixings and (b) schematic representation of minimum distance requirements for the glass holes. Reproduced from [1] under the terms and conditions of CC BY license

Results & Conclusions

The parametric numerical analysis based on Fig. 3 shows that the typology, number, position and distribution of mechanical point fixings, as well as the local (non-linear) stiffness due to interposed gaskets and gaps (i.e., to avoid local stress peaks in the region of glass holes) are influencing parameters that can severely affect the final restraint condition for the examined LR glass beams, and thus are responsible of remarkable modifications in their theoretical critical buckling moment M_{cr}. The developed study and the proposed methodology proves that the normalized LTB performance of LR glass beams is indeed rather stable, thus allowing to detect practical empirical models. Fig. 4, for example, shows a normalized comparative LTB investigation for selected geometry / stiffness parameters. Extended configurations are further discussed in [1].



3. FE numerical modeling of a glass beam with LRs in LTB (n_b = 1, x_b = L/2): (a) geometrical detail of the mechanical (spider) restraint, with evidence of (b) the proposed mechanical characterization of gaskets (detail "B" from (a)). In (c), an example is proposed in the form of local FE numerical model for the LR stiffness characterization and analysis of a "detail B" point-fixing (ABAQUS/Standard). All the figures are reproduced from [1] under the terms and conditions of CC BY license



4. Normalized comparative LTB calculations for LR glass beams with mechanical point fixings variably positioned on the span and with variable local restraining stiffness K_b. Reproduced from [1] under the terms and conditions of CC BY license

[1] D. Santo, S. Mattei, C. Bedon (2020). *Elastic Critical Moment for the Lateral–Torsional Buckling (LTB) Analysis of Structural Glass Beams with Discrete Mechanical Lateral Restraints*. **Materials**, 13(11), 2492; doi: 10.3390/ma13112492