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Flexural behavior of hybrid glass beams with rectangular cross-sections

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HIGHLIGHTS

- Experimental flexural tests on hybrid glass beams.
- Shear to moment interaction.
- Bearing capacity.
- Analytical model.

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ABSTRACT

An experimental investigation regarding the flexural and the shear behavior of glass beams with length 900, 1300, 1700 mm and rectangular cross-section is presented and discussed. Rectangular cross-sections were obtained by assembling three float glass panels of depth 200 mm and thickness 6 mm through an acrylic adhesive with an effective depth of 19.52 mm (6 + 0.76 + 6 + 0.76 + 6 mm). Some specimens were also reinforced internally with steel plates of thickness 6 mm and depth 25 mm and thickness 6 mm and plates of thickness 6 mm and depth 50 mm placed at the bottom portion of the beams for the entire length of the beams themselves. Three specimens for each investigated series were tested in flexure focusing on the flexural and shear response through the determination of the load-deflection curves, and the crack patterns at rupture. The shear span to depth ratios a/d were 2, 3 and 4, respectively. In the paper an analytical model is also presented for a preliminary design of composite glass beams able to predict the ultimate load including limit states due to glass cracking, flexural failure with glass crushing or plates yielding, shear compression and diagonal tension failure. This model can be useful to perform simulations in order to investigate the structural resistance of hybrid glass beams to the varying of the geometrical characteristics of beam, of the reinforcement area and on the type of reinforcements.

1. Introduction

In every structural application of glass, in which members (beams, column, plates) are obtained by assembling single glass sheet or web and flanges constituted by single panels or laminated (LG) glass members with flexible interlayers (e.g. PVB), one important aspect in their design is the choice of the type of glass and of the thickness of the single layers to ensure that the brittle failure mechanism is characterized by a progressive collapse. Utilizing the design principle of the redundancy of glass elements, it is possible to ensure a safe design of glass members [1–8].

For a safe design, glass beams have to be assembled in such a way to ensure that any failure of a glass plate is not a catastrophic event, but simply activates secondary, redundant glass elements. Another important aspect to take into account in the design of glass beams is the connections between two or more glass elements and the choice of adequate thickness and strength of each glass sheet to form composite section [2,4,7,9]. In addition many studies have investigated the different behavior of hybrid beams reinforced with steel reinforced polymer or pultruded GFRP [10–12] or the interaction between concrete and glass [13].

To form composite glass beams, as already mentioned, it is necessary to assemble glass flanges and glass webs using glued or bolted joints [14–18]. Glued joints, unlike bolted joints, afford many important advantages for brittle glass, such as uniform stress distribution along the larger connection area, the absence of drilling holes in the glass or the possibility of putting together materials with different mechanical and thermal properties. The shear strength of the connection due to bond effects is influenced by many factors [14,15,18] such as: – adhesion of glue to the substrate; – cohesion of glue; – joint dimensions and geometry;

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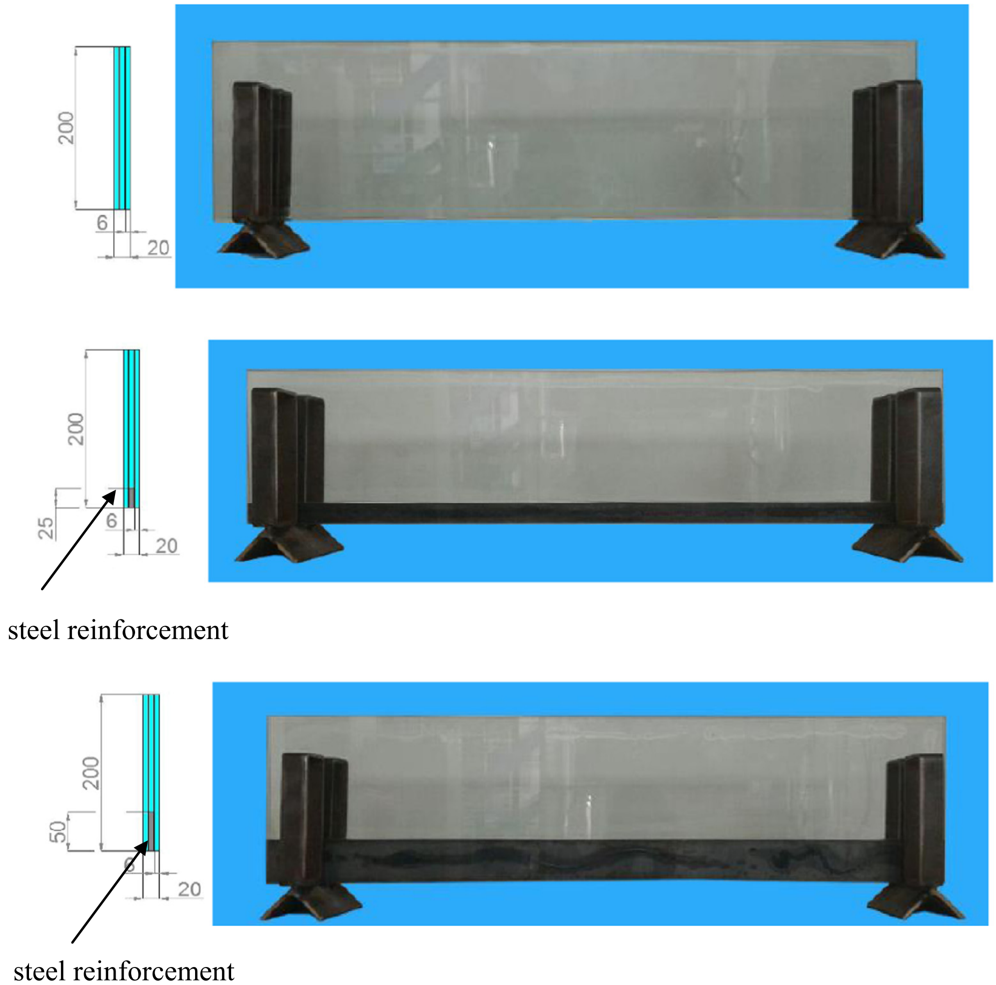

Fig. 1. Glass beams examined.

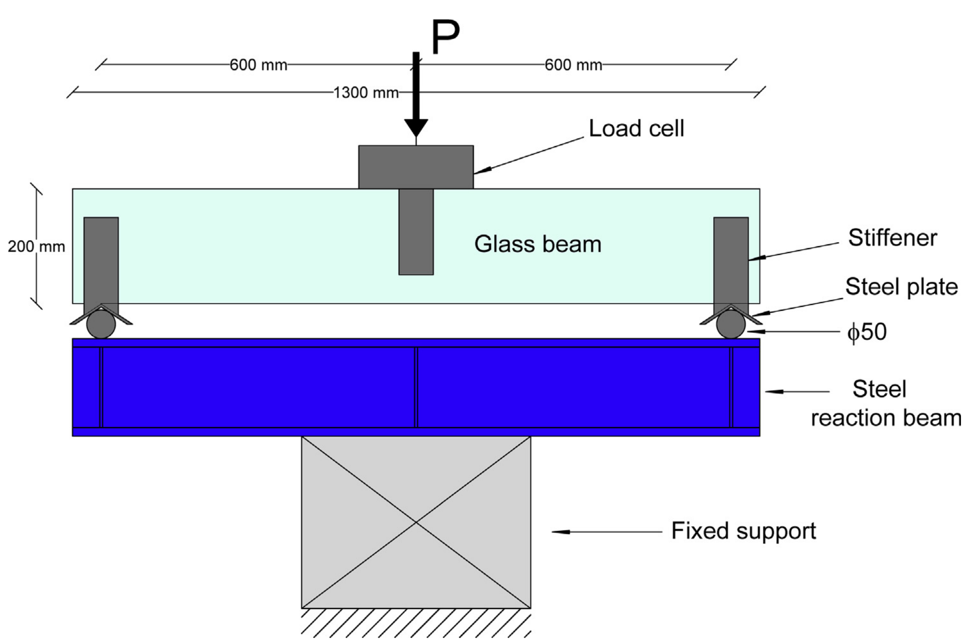

Fig. 2. Loading scheme and test set up.