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A proposal for an arch footbridge in Venice made of structural glass masonry

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Abstract

Glass presents high compression strength and excellent durability, but its intrinsic brittleness renders its use in structural applications quite problematic. In order to increase its apparent ductility, a system is conceived of, in which "bricks" made of float glass, either laminated or not, are connect by "mortar" joints of epoxy resins. Uniaxial compression experimental tests have been performed on cubes made with such a "glass masonry" and, to compare, on cubes formed by dry connected glass tiles. The compression strength of the composite package is about one half of that of the dry cubes, but the ductility is increased by one order of magnitude due to a well-marked strain-softening branch. In the post-critical response a crucial role is played by the lateral stress provided by the material filling the abreuvoirs.

The considerable compression strength and the so-obtained ductility are combined in the design of a fixed-arch 50 m-span footbridge, crossing the Grand Canal in Venice. At least from a theoretical point of view, the possibility of constructing arch footbridges for short or medium span entirely made of glass has been confirmed.

Keywords: Structural glass; Bridge design; Glass masonry; Glass arch; Footbridge; Venice; Brittle material

1. Introduction. A glass bridge in Venice

Preservation and modernization of natural, historical and artistic sites, reduction of the environmental impact and, why not, aesthetic appeal, are major issues in modern architecture, especially in the design of large works such as bridges. The possibility of constructing a transparent structure that may meet the aforementioned requirements seems to be a *panacea*, so efficient but difficult to achieve. Glass is certainly the material for such a purpose: it is transparent and elegant, it is durable, it is elastic and stiff (Young's modulus of the order of 70 GPa), it exhibits a notable compression strength (of the order of 200 MPa) and tensile strength (of the order of 100 MPa for tempered glass). However, two major problems prevent, or at least restrict, its use in structural applications. First of all its intrinsic brittleness, which impedes the possibility of accommodating stress concentrations [17]; secondly, its manufacturing process, which in practice supplies only flat slabs of small size, whose connection *in situ* is so difficult as to hinder the construction of massive structures. This is why, nowadays, glass is usually associated with load-bearing skeletons made of metals or polymers, but its use as a structural material appears yet to be only partially appreciated.

Most recently, a few proposals have been advanced for the construction of glass bridges. The Bridge of Glass designed by Dale Chihuly is a 150 m-long pedestrian bridge linking downtown Tacoma, Washington, to the city's waterfront, the Thea Foss Waterway. It is quite a piece of art soaring seventy feet into the air, but the load bearing structure is made of steel and the glass panels play, at most, a secondary structural role.

As a further example, the glass balcony-like Skywalk, which will extend over the edge of the Grand Canyon 1200 meters above the Colorado River, is scheduled to open to the public in 2007 as part of a new resort on the reservation. This is a remarkable transparent structure, but its load bearing capacity is again assigned to a traditional steel work.

But it is in Venice that, because of its long history of glass manufacturers, the idea of a glass bridge seems to be the most suggestive. A transparent footbridge connecting the two banks of the Grand Canal in proximity to the railway

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