A Novel Design Concept for Connections in Glass: Structural Integrity of Glass Reinforced with Externally–Bonded GFRP Laminates

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Abstract

The paper reports experimental results of the load response and failure behaviour of open-hole annealed glass tensile test specimens reinforced with adhesively-bonded GFRP laminates. The results show that the bonded GFRP has potential to strengthen stress concentration features in glass by either arresting the cracks developed in the critical zone or eliminating the failure from the vicinity of the critical area. It is anticipated that the findings of this research could be effectively used to develop reinforcement strategies for critical joints in glass structures.

Keywords: glass; GFRP; joints; reinforcement; strengthening

1 Introduction

Owing to the fascinating physical, optical and chemical properties of glass and its potential for delivering energy-efficient building envelopes, glass has become one of the most preferred construction materials in modern buildings. However, due to the brittle material behaviour of glass, the design and construction of the connections between the glass facades and the underlying main structure pose major challenges. Mehanically-fastened joints in glass lead to stress concentrations, and as a result, the strength of structural members is often governed by that of the joints. On the other hand, structural adhesive joints are relatively unproven in glass structures.

Inefficiency of the connections is the main difficulty compared to other construction materials, such as concrete, steel and timber. In-service movements in the connections between glass facades and the main structure, eccentric loads and dimensional tolerances will inevitably result in additional load being transferred through the facade elements which they are not designed to carry. The aim of this project is to demonstrate that stress concentration features of glass such as bolted joints can sustain higher loads, even after microcracks form, if the joint area is reinforced with Glass Fibre Reinforced Polymer (GFRP) straps. The efficacy of GFRP reinforcement in increasing the load capacity and the ductility of open-hole glass tensile test specimens are presented in the paper. It is anticipated that the findings of this paper could be effectively used to develop reinforcement strategies for joints in glass.

2 Experimental Study

The load response and failure behaviour of open-hole annealed glass tensile test specimens reinforced with two different GFRP reinforcement configurations are presented: (1) partial reinforcement where GFRP strips were bonded on both sides of the hole along the loading direction, and (2) full reinforcement where a GFRP laminate was bonded across the full width of the tensile test specimenIn. The strength and ductility improvements in the reinforced test specimens were compared against that of unreinforced reference test specimens.

2.1 Test specimens

2.1.1 Reference annealed glass test specimens

A dogbone shape was chosen as the test specimen geometry of the uniaxial tensile test specimens. 4 mm thick annealed glass was used and the width

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