



## Tensile strength of the bent portion of vinyl ester GFRP rebars

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### Abstract

Glass-fibre reinforced polymer (GFRP) rebars are increasingly used in concrete as an alternative to conventional reinforcing steel, as corrosion issues can be excluded, and the application limits extended. Besides straight reinforcing bars bent rebars are used, e. g. as stirrups to absorb shear stresses. However, there is only a limited number of studies investigating the load bearing and deformation behaviour of bent fibre-reinforced polymer (FRP) bars.

This study aims to experimentally determine the tensile strength of bent vinyl ester GFRP rebars. The failure of bent GFRP rebars occurs primarily in the corners, as a substantial reduction in tensile strength is noticeable at the bent portion. Therefore, tests are performed on L-shaped bent GFRP bars embedded in concrete blocks and subjected to tensile pull-out forces. The GFRP bars examined consist of a matrix of vinyl ester resin and a nominal diameter of 12 mm. A total of six test specimens were examined, with three concrete blocks reinforced with reinforcing steel and three unreinforced in order to investigate the influence of a reinforcement on the failure mode of the test specimens. The results of this study provide a significant contribution to the load-bearing capacity of concrete components reinforced with GFRP bars and show the relevance of the bent portion or the load transfer of the stirrup in concrete.

**Keywords:** FRP; GFRP; vinyl ester; bent GFRP rebars; bending; experimental testing; tensile strength

### 1 Introduction

Fibre-reinforced polymer (FRP) rebars present an alternative to conventional steel reinforcements, eliminating the need to protect the reinforcement from corrosion and allowing lighter and slimmer structures to be realised due to the lower dead weight of FRP. Especially glass fibre-reinforced polymer (GFRP) rebars are widely used owing to the lower cost of glass fibres. While extensive research has been carried out on straight GFRP rebars and first projects have already been implemented, the performance of bent GFRP rebars is hardly known [1]. However, the implementation of complete reinforced concrete structures requires both straight and bent rebars.

In this study, the strength of the bent portion of vinyl ester GFRP reinforcing bars is determined experimentally. L-shaped GFRP rebars with a diameter of 12 mm and a bend of 90° are investigated.

The tests are based on the specifications of Annex E (normative) of the CSA S807:19 “Method of test for determining the strength of the bent portion of FRP reinforcing bars” [2]. A total of six specimens are examined, whereby three specimens fulfil the specifications of CSA S807:19 and are reinforced with reinforcing steel, while three concrete blocks are unreinforced.

The aim of this study is to determine the strength of the bent portion of the vinyl ester GFRP rebars