FLAX FIBERS FOR STRENGTHENING OF TIMBER STRUCTURES FINITE ELEMENT MODELLING

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KEYWORDS: Natural fibers, glulam, Flax, Tension perpendicular to the grain, Strengthening, Fictitious crack model, Flax

INTRODUCTION

A Finite Element Analysis (FEA) using the commercial finite element package ABAQUS [1] was carried out to model small prismatic glulam specimens and curved glulam beams reinforced with flax fibers composites. Two- and three-dimensional models were used to study the elastic and the softening response of the specimens. Damage and crack opening was modeled based on the "fictitious crack model". Cohesive elements together with a traction separation law were used. The model of glulam specimen where high tensile stresses perpendicular to grain are expected should consider the cylindrical orthotropy (annual rings) assumption. The tensile stresses perpendicular to grain obtained with FEA can be compared to those from experiments. Cohesive interface elements have been used successfully to model the crack formation and propagation in glulam under tension perpendicular to the grain.

BODY OF THE ABSTRACT

Background

The weak mechanical properties of wood in tension perpendicular to the grain are often the origin of catastrophic brittle failure. In order to enhance the design value given by the fifth percentile of the probability density function, decrease the mechanical variation and provide the structure a more ductile-like failure, fibres reinforced polymer (FRP) composites have been used to strengthen glulam timber specimens and increase of the mechanical properties have been reported most of the time [2].

Finite Element Modelling

The FEA is based on the results from the curved and pitched beams investigation carried out by [3], and on tensile tests on prismatic glulam specimens carried out by the author. The geometry of the two structures is shown in Fig.1:

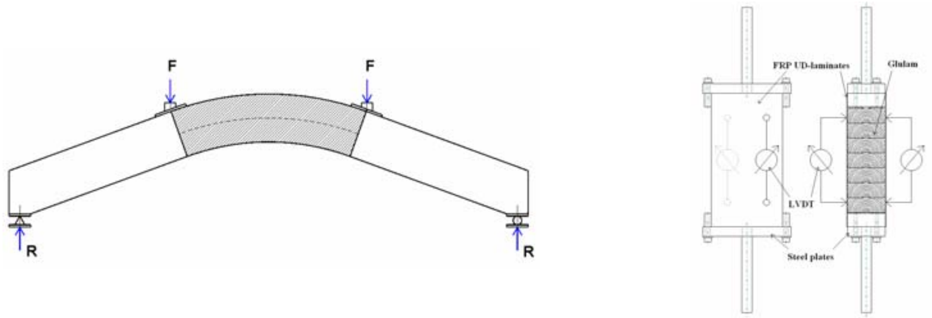

Fig. 1: Curved glulam beam and prismatic glulam specimen

In order to determine the load share taken by the reinforcement during loading of reinforced specimens, a damage model is done. The model is based on the study of the linear elastic response of prismatic glulam specimens and curved glulam beams. The linear elastic model was done in order to determine where in the specimen the failure perpendicular to the grain was most likely to occur. From the linear elastic model results, a fictitious crack model, first introduced by [4] was implemented with cohesive elements in ABAQUS. Contrary to linear fracture mechanics, it is assumed that the crack occurs in a plane (interface) where the variation of cohesive stresses, governed by a specific traction separation law, generates the damage of the material and the decrease of stress transfer. Both rhombic orthotropic and cylindrical orthotropic models have been investigated.

Results

The stiffness and the tensile stress distribution in the glulam have been investigated. The models where rhombic orthotropy is assumed (no annual ring effect) predict constant tensile stresses perpendicular to the grain with values comparable to the experimental average values reported by the author and by [3] and [5]. Higher tensile stresses are reported at mid-width when annual rings are considered in the model. The stiffness increase and load at failure are in good agreement with the experimental results in the damage model. At equal load, the tensile stresses perpendicular to the grain in the glulam are significantly lowered for specimens reinforced FRP (Fig.2).

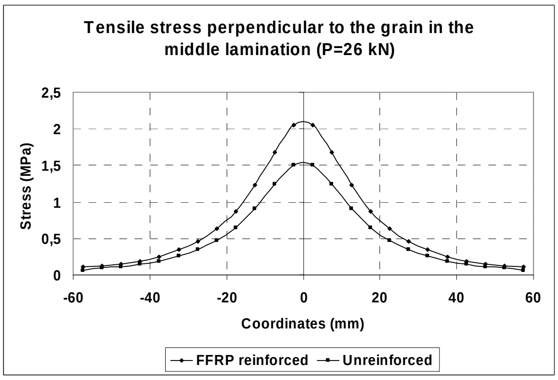

Fig. 2: Tensile stress perpendicular to the grain along the width (prismatic glulam specimen)

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