NUMERICAL ANALYSIS OF THE CARPENTRY JOINTS FOR DIFFERENT LOAD SCHEMES

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1. Introduction

Wood is one of the basic building materials. It is characterized by orthotropic properties. The strength and elasticity of the wood depends on the humidity, temperature and density [1]. The approach taking into account the effect of temperature and humidity on the strength of wood is presented in [2]. In this paper it is focused on numerical analysis of the historical and traditional carpentry joints made from pine wood using the orthotropic structure. The carpentry connections are customized to assure loading from one element to another, as well as provide the appropriate position of the elements relative to each other. It is distinguished many types of carpentry connections depending on the form and performed function [3]. This paper is related to selected corner connections in crowned constructions. The numerical analysis has been performed for different load schemes to determine the areas of maximum stress and the vulnerable zones.

2. Geometry and material

The numerical analysis has been carried out for carpentry joints produced from the pine wood. The geometry of one of the connections (the long-corner dovetail connection) has been presented in Figure 1. The dimensions of each timber are 7.5 x 13.5 x 100 cm.

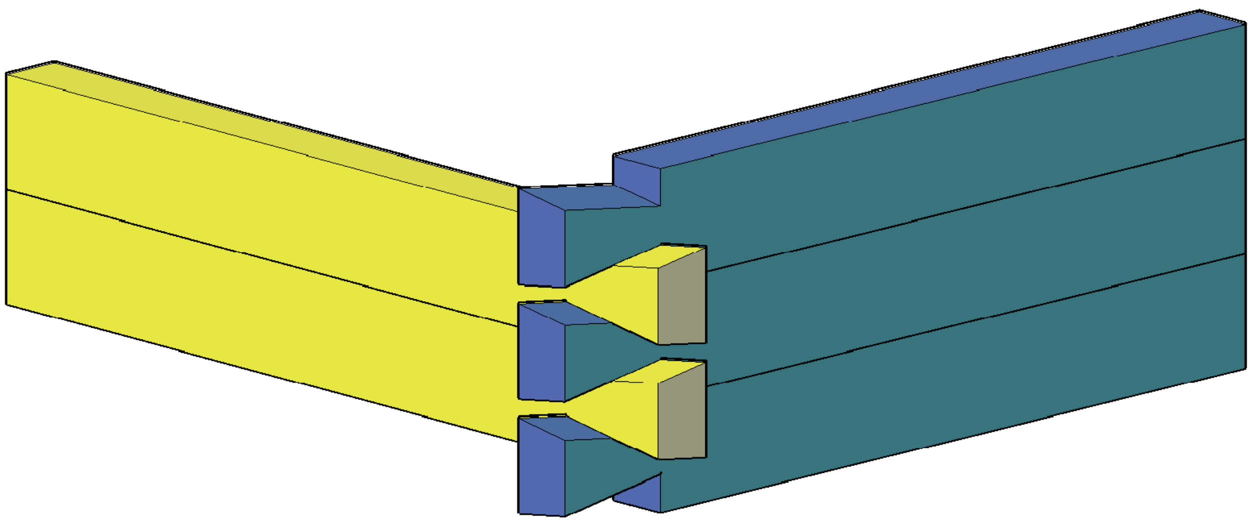

Fig. 1. Long-corner dovetail connection.

Due to the different mechanical properties depending on the anatomical wood direction, the calculations have been performed using orthotropic material. In Table 1 nine independent material constants of the pine wood have been presented. The following notation depending on the wood directions has been used: T – tangential direction, R – radial direction and L – longitudinal to the surface of each layer of the fibres [4]. On the basis of these parameters particular elements of the constitutive matrix have been determined [5]. The calculated matrix elements have been used to define the orthotropic material in the MSC.Marc programme.

Young's moduli	Kirchhoff's moduli	Poisson's ratio
$E_L = 8280\,\text{MPa}$	$G_{LR} = 406\,\text{MPa}$	$\mu_{LR} = 0.316$
$E_T = 563\,\text{MPa}$	$G_{LT} = 381\,\text{MPa}$	$\mu_{LT} = 0.347$
$E_R = 845\,\text{MPa}$	$G_{RT} = 41\,\text{MPa}$	$\mu_{RT} = 0.469$

Table 1. Material parameters of pine wood [6].

3. Numerical analysis

The numerical static analysis has been carried out in the MSC.Marc programme. In order to select the most endangered areas of damage, calculations have been performed for different boundary conditions and different load schemes of the carpentry joints. In the numerical calculations between individual timbers of the connections have been defined the phenomenon of contact. All logs have been modelled using three-dimensional solid elements with the enhanced density of the finite element mesh inside joints corners.

4. Results

As part of this work is planned to analyse the various types of connections commonly used in currently preserved objects of wooden architecture. The selected carpentry joints will be performed for different load schemes and for different boundary conditions. On this basis it will be possible to determine areas of greatest stress in the contact zones and especially vulnerable damage zones. This knowledge will be allowed to search the optimal carpentry joint which could be used not only for modernization of historical structures but also in modern engineering constructions.

5. Acknowledgment

This work has been carried out within the project "Geometric – strength analysis of historical carpentry joints". The project is financed by the resources of National Science Centre (Poland) given according to decision No. 2015/17/B/ST8/03260.

6. References

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