Quantitative Modeling Of Joints Of Tensile Elements Of Wooden Structures

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Abstract

The article describes the details and results of a test conducted to increase the strength of the connection by expanding the bonding surface in the joints of wooden elements, and to study the deformability of wooden structural joints using the ANSYS Workbench computer program.

Keywords: Wooden joints, fasteners, tensile elements, strength, deformation.

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1. Introduction

Today, innovative technologies for the development of wood and other natural, environmentally friendly structures play an important role in construction worldwide. The creation, improvement, practical research and application of effective combinations of elements for wooden structures are of great importance. Improving the joints of wooden structural elements and increasing the strength of joints is becoming one of the pressing problems.

In particular, special attention is paid to the creation of new types of joints of wooden structural elements, the introduction into practice of joints of wooden structural elements that are resistant to stress-deformation, ensuring energy and resource efficiency, and improving their adaptability to operating conditions and technological properties. Worldwide, great attention is paid to the strength-deformation state of joints of wooden structural elements and their good performance. Ensuring high strength of joints of wooden structural elements and stability of joints in the state of strength-deformation is considered one of the important tasks. In particular, special attention is paid to improving the joints of wooden structural elements, including using local raw materials [6].

2. Experimental Research

When modeling the studied joints in the ANSYS Workbench software package, it is necessary to take into account the conditions of the wood-steel boundary connection. For this, Frictional type double connections are used, that is, a nonlinear connection that takes into account the friction coefficient. The value of this coefficient for the pairs in the framework of this study is as follows:

for a wood-steel (screw) pair k=0.6;

The requirements for the strength characteristics of the materials are based on data obtained from a series of preparatory tests and from the materials of the ANSYS Workbench library. Below are their strength characteristics:

Type II wood element:

density R0=500 kg/m3;

flexural (Yung) modulus: $E1$ = 11000 MPa; $E2$ = 370 MPa;

Poisson coefficients: $\mu=\mu12 = \mu13 = \mu31 = \mu32 = 0.45$, $\mu21 = \mu23 = 0.02$;

shear modulus: $G12 = G13 = G23 = 500$ MPa.

Steel grade 20G2R (ANSYS Workbench library):

density R0=7850 kg/m3;

elasticity (Young) modulus: E = 227800 MPa;

Poisson's ratio: μ = 0.3;

shear modulus: G = 80769 MPa.

Based on the series of experiments, the loads were given differently for comparison with the results of experimental studies:

To simulate the testing of local samples for the extraction of screws from a wooden massif, the increase in the displacement of the bolt tensioning plate was 10 mm per minute.

To simulate the testing of joints of wooden structural elements, the load was applied to one of the wooden structures in steps of 2 kN. Quantitative studies of screw joints in the extraction of wood-board massif

In order to compare and verify the similarity of the mathematical model of the connection and experimental studies, a quantitative modeling of the connection of wooden structural elements in the zones of the connections of tensile structural elements was carried out. To simplify the identification of samples, the following symbols were introduced:

1. T-1 - the existing connection;

2. T-2 - the improved version recommended by us;

3. T-3 - the improved version recommended by us

The general appearance of the existing T-1 series connection in experimental tests and the computational model in the ANSYS Workbench program and the view of the existing connection divided into linear finite elements with a size of 25 mm are presented in Figure 1.

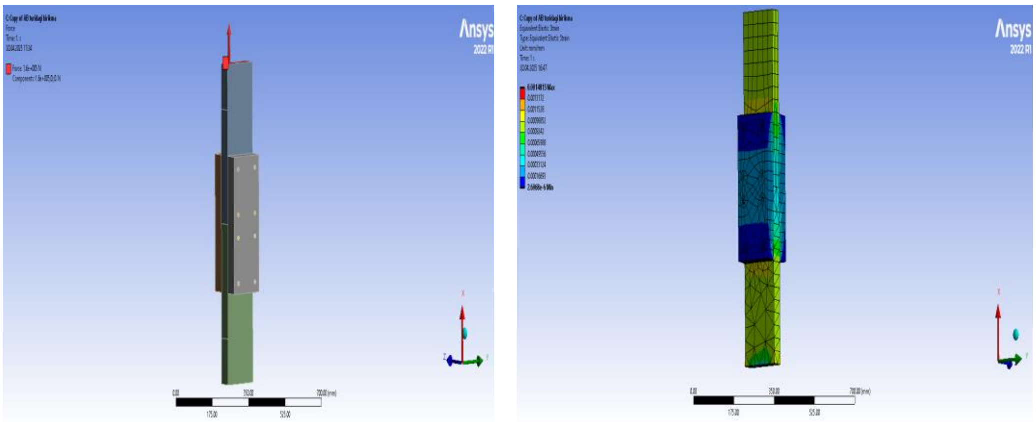


Figure 1. General view of the existing joint in ANSYS Workbench and the view of the joint separated into elements.

The general appearance of the improved T-2 series joint in experimental tests and the computational model in the

ANSYS Work-bench program, the T-2 series joint divided into linear finite elements with a size of 25 mm, are presented in Figure 2.

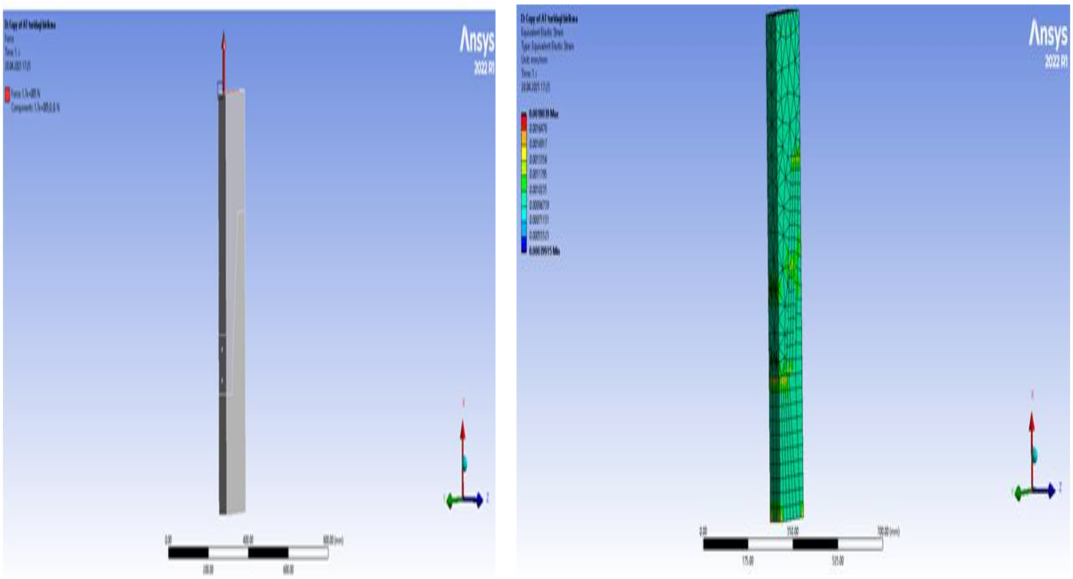


Figure 2. General view of the T-2 series joint in ANSYS Workbench and the finite element view of the joint.

The general appearance of the improved T-3 series joint in experimental tests and the computational model in the ANSYS Workbench program and the T-3 series joint divided into linear finite elements with a size of 25 mm are presented in Figure 3.

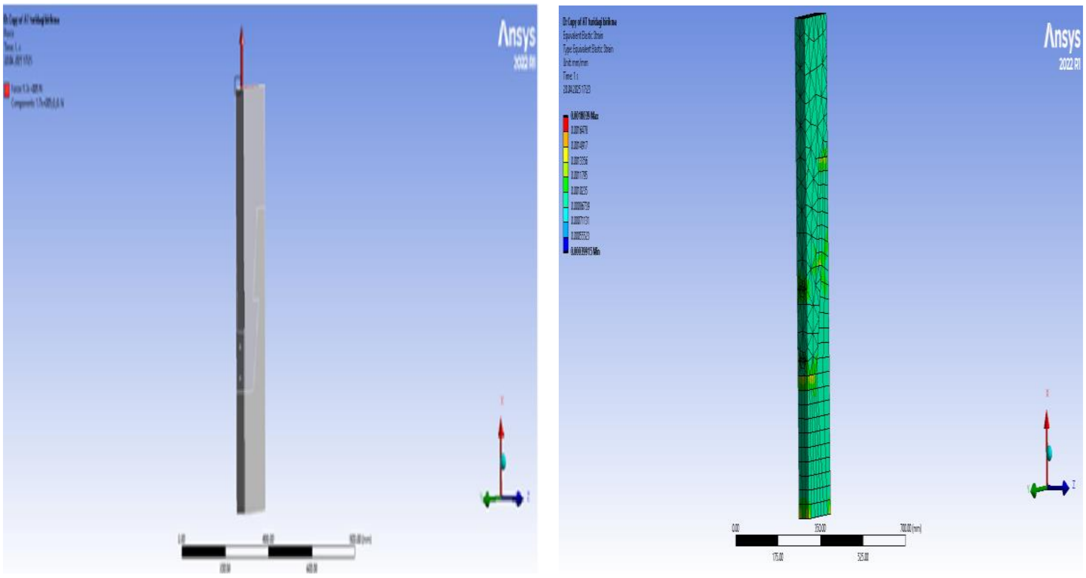


Figure 3. General view of the T-3 series joint in ANSYS Workbench and the view of the joint divided into finite elements

3. Results

According to the calculation results, diagrams of deformed joints, graphs of normal and shear stresses in wood were constructed. Two nonlinear design problems for joints of three series were formulated in the Ansys Workbench calculation complex. As a result of quantitative studies, the maximum displacements from bending loads, specific relationships for normal and shear stresses in wooden elements of the current T-1 and improved and recommended T-2, T-3 series are presented in Figures 4, 5 and 6.

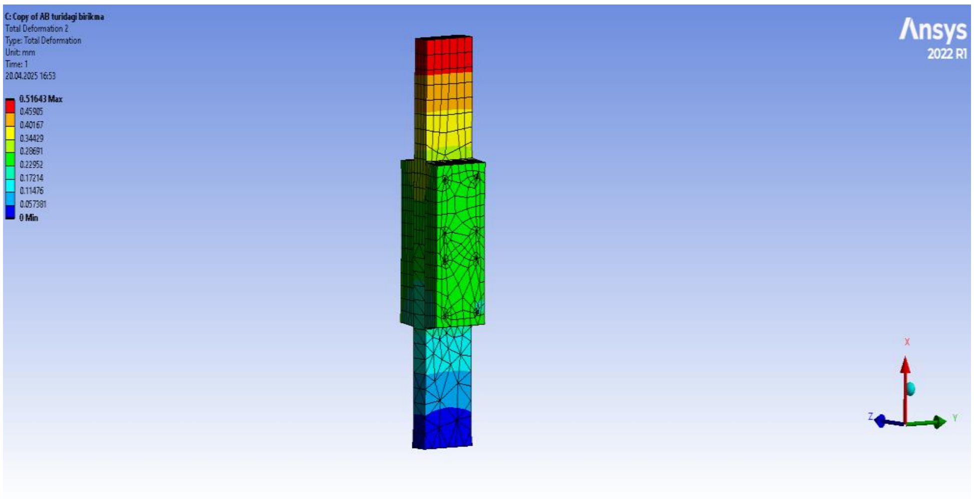


Figure 4. Tensile deformation of the T-1 series joint in use

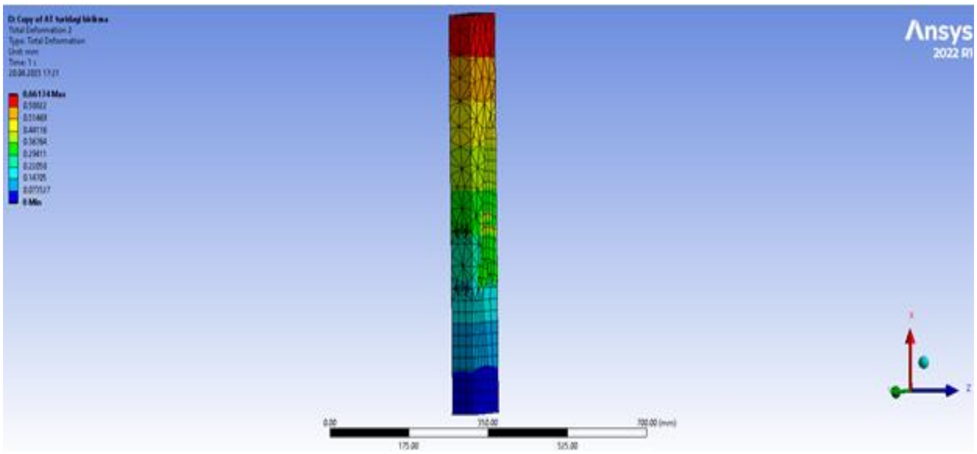


Figure 5. Tensile deformation of the proposed T-2 series joint

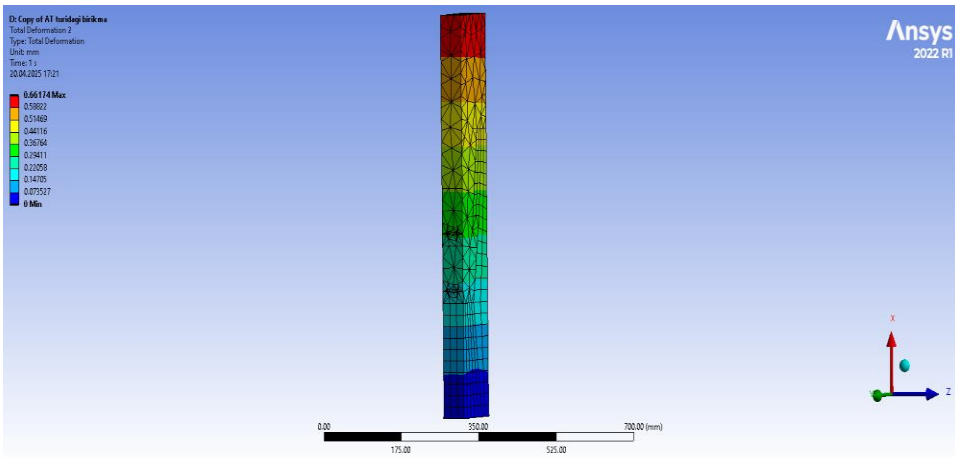
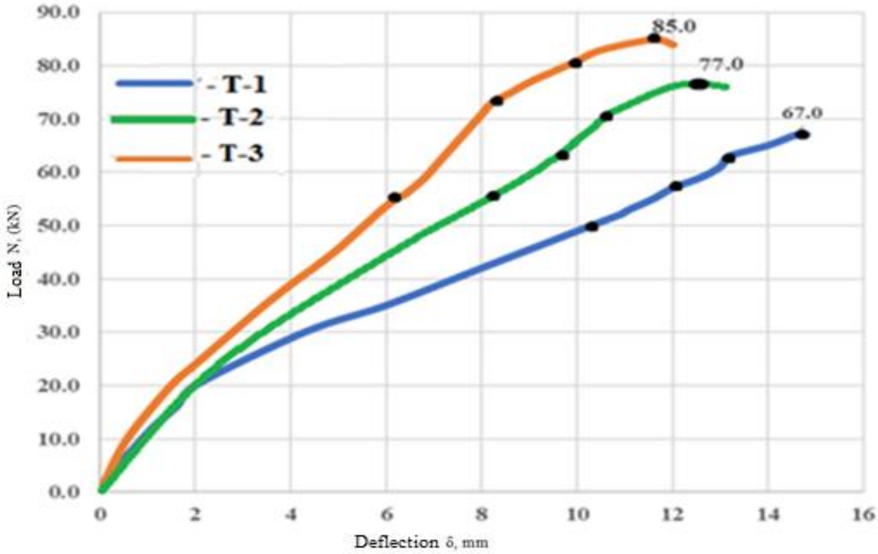


Figure 6. Tensile deformation of the proposed T-3 series joint

The results of the calculations and the results of the tensile tests of the composite meshes and series are presented in Figure 7, and the experimental test values are presented in Table 1.



The values of the performed calculations are shown in Table 1.

Table 1. Values of flexural element combinations calculated in a computer program

Serie	Sample	In bending disruptive loading P, kN	Marginal displacement in flexion δ, mm
1	**2**	**3**	**4**
T-1	1	50	12
	2	58	13
	3	63	15
T-2	1	55	9.9
	2	62	10.4
	3	71	12.2
T-3	1	56	8.3
	2	**73**	**10**
	3	80	11.9

4. Conclusions

Analyzing the load-bearing capacity and bending strength of the joints, it was found that the tensile strength of the improved and recommended T-2 series joint is 14.6% stronger than the current T-1 series joint calculated in the ANSYS Workbench program, and the tensile strength of the T-3 series joint is 11.6% stronger than the recommended T-2 series joint.

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