INITIAL RESEARCH OF STRENGTH OF THE WOODEN PALLETS

Uldis Spulle, Jānis Ošs, Valentīns Pušinskis
Latvia University of Agriculture
e-mail: uldis.spulle@e-koks.lv

Abstract

The manufacture and export of pallets is one of the largest sectors of the wood industry. For the manufacturing of pallets mainly softwood - spruce (*Picea abies* L. Karst.) and pine (*Pinus sylvestris* L.) wood - materials are used. The price of those materials is increasing. It could be better for the production of pallets if the manufacturers could use hardwood - alder (*Alnus incana* L. Moench) and aspen (*Populus tremula* L.) wood materials. The reasons for that could be that these materials are not so expensive and that softwood materials could be used more in the wood industry where it is more necessary. But at that point more information about the physical and mechanical properties of hardwood materials is needed. Basing on the previous research on quality and mechanical properties of softwood and hardwood and on the present research work the practical and theoretical values of deflection and strength of pallets have been assessed. The research enables us to optimize the preparation for pallet production.
The aim of the research is to find out the strength of the pallets without destroying.
Key words: pallet, deflection, strength.

Introduction

In Latvia, for manufacturing of pallet components there are currently used: the round assortment of softwood (the spruce and the pine) of a small diameter (10...16 cm) and the packaging logs from hardwood (the aspen and the alder) with diameter 10...40 cm, as well as the thin side boards 14...19 mm in thickness, supplied by sawmills.

In the process of maintaining the pallets, particularly important is their bending strength, as well as stability. These indices to a great extent depend on the bending strength of the components and indices of the modulus of elasticity. As the above indices of the wood for different species of trees are different (Уголев, 2001), then in the pallet constructions sizes of the cross-section of the used components depend not only on the heaviness and character of loading, but also on the strength and elasticity of the used wood.

Therefore, the issue of the strength and stiffness of the demanded pallets is topical. Sizes of the components are determined by the heaviness and character of the loading taking into account the bending strength and the modulus of elasticity of the used wood, as well as price of the wooden materials for the definite species.

Strength of the pallet depends on the variety of species of the wood. Properties of the wooden materials used for pallets during the operation change due to the duration of the load (permanent, continuous, average in size, short-term, instant) and humidity.

Calculating wooden constructions, the main task of which is to secure sufficient strength and stability in the loading of the appropriate length in the definite moisture conditions, value of the strength calculation of the applied material is used (Ozola, 2001).

The maintenance conditions for wooden constructions are divided into three classes:

1) Class 1 which is characterized by air temperature of 20 °C and the relative humidity of the air up to 65%, allowing the increase to be above 65% only a couple of weeks per year. The absolute humidity of the wood in such conditions does not exceed 12%;

2) Class 2 which is characterized by air temperature of 20 °C and the relative humidity of the air up to 85%, allowing the increase to be above 85% only a couple of weeks per year. The absolute humidity of the wood in such conditions does not exceed 20%;

3) Class 3 which is characterized by a higher humidity than for Class 1 and Class 2. Usually to Class 3 correspond

Table 1

Pallets footprints recognized by LVS ISO 6780

Size of the pallet, mm	Region of application
1,200x1,000	Europe, Asia
1,200x800	Europe
1,140x1,140	Australia
1,100x1,100	Asia
1,067x1,067	Northern America, Europe, Asia

constructions which are located outdoors. For covered constructions, conditions of Class 3 are applied only in circumstances when there is a source of humidity in the premise.

Pallets are characterized by several parameters, from which the most important are as follows: size of the pallet, mass, mechanical strength, stiffness, and price. The most essential index is price which is directly affected by the price of the raw materials components, blocks and connections - for the pallets. Pallets are carrying constructions and their mechanical properties depending on both quality of the pallet components and cross-section sizes of the components. For freight, in the world basically 6 standard sizes of pallets are used (see Table 1).

For description of sizes of the numerous pallets and the mechanical properties of the pallet cross-section sizes, the proposed solution is to determine the mechanical strength of the pallets using software.

The carried out research and the elaborated software allow obtaining deflections of pallets and strength to optimize the pallet components in a comparatively short time.

Materials and Methods

At the previous research preparation of the pallet components from softwood (spruce and pine) and hardwood (aspen and alder) of strength were carried out accordance with the standard LVS EN 408:2003 requirements. As a result of the research, the average values of the bending strength and the modulus of elasticity are obtained. By calculating the statistical indices, the normative (5% percentile) values of the bending strength and the modulus of elasticity are obtained, correlation of the bending strength and the modulus of elasticity are found.

By calculating strength of the pallet at a definite load, it is advisable that the actual strain does not exceed the threshold of 20...25 $N \cdot mm^{-2}$.

Such an increased strength is accepted taking into account the fact that in order to simplify the calculation, resistance of the bottom deck boards is not taken into account.

The load, which the pallet can hold in maximum, is determined taking into account values of the actual load and strain as well as the strain (5% percentile) value. The normative (5% percentile) value is determined experimentally.

At the same time the calculation program 'Pallet Testing' (PT) is created applying the programming language C# (C sharp) (Liberty, 2005). C# is a modern, object-centered programming language which provides the programmers to quickly form wide-scale applications for the new Microsoft®.NET platform. The platform is provided with tools and services and is used for computations and communication. C# is created by combining C++ and Microsoft Visual Basic® (MacDonald, 2005). By C# you can form wide-range components starting with a high level business and ending up with objects of the system level.

Simultaneously with the theoretical calculations of the pallet strength (Lavendelis et al., 1970), practical research was carried out for pallet loading by loading pallets and determining deformation (deflection) values. The obtained deformation (deflection) values are used for the theoretical calculations of the pallet strength.

In the tests, one type - the four way pallets are used, the dimensional sizes of which are as follows: width-1200 mm, length-800 mm (see Figure 1).

Sizes of the pallet boards:

Pallet No. 1
- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 5 pieces;
- sizes of top stringer boards: width - 100 mm, thickness - 23 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 18 mm, number - 3 pieces;
- height of the block - 75 mm.

Pallet No. 2
- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 7 pieces;
- sizes of top stringer boards: width - 160 mm, thickness - 18 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 18 mm, number - 3 pieces;
- height of the block- 75 mm.

Pallet No. 3
- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 7 pieces;
- sizes of top stringer boards: width - 120 mm, thickness - 15 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 16 mm, number - 3 pieces;
- height of the block - 75 mm.

Results and Discussion

Results of research of the theoretical pallet testing

The calculation program is created for its user to be easily understood and used. Currently, in the calculation method of the pallet strength, computations for two types of pallets are set: for the two way pallet and for the four way pallet (see Figure 1).

Pallets differ in their construction and type of lifting: the two way pallet is lifted only from the front, but the four way pallet can be lifted from the front and the side.

Supplements are easily attached because the program consists of attachable models, for instance, calculation for pallets of a different construction is developed and as a model it is added to the basic data of the program. It enables

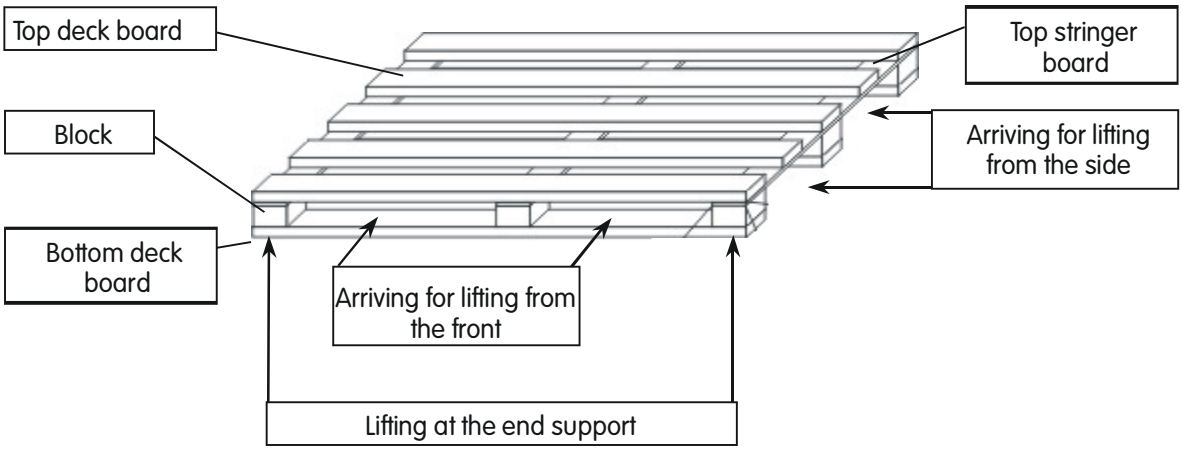

Figure 1. The four way pallet.

to easily improve and to perfect operation of the program without interrupting structure of the program.

The program consists of two parts:

1) the part of data input (see Figures 2, 3);

2) the part of calculation (see Figure 4).

In the part of data input, data, which are needed for calculations, are fed in. Due to logical considerations, sizes, which depend on the size of the part, are not required. In the input part of data, the pallet is visually reflected where the required data are specified in the input field (see Figure 3). This enables to decrease possibility of faulty data input and allows the user to easier orientate in the program and ensures a correct result of calculations. Moving along the input fields, the place in the pallet is visually reflected and sizes of the places, which are necessary to feed in, are specified. In the calculations of the pallets, a method is introduced that the width of the top deck board can differ.

For the calculations to be precise, a table is introduced in the program which feeds in sizes of all the top deck boards (only in the case when they differ). For every pallet only these input fields are activated which are needed for the calculations (see Figure 3).

After the input of data, the process of calculations follows, which is visually reflected in the calculation part (see Figure 4). Under the figures, data are specified according to their type of loading. Strength and deflection are specified in millimeters for every loading diagram and the maximum weight to be allowed is specified with which it is possible to load the pallet.

The obtained results of calculations can be displayed in the MS Word program. The display function is built into the calculation program. Using MS Word opportunities, it is possible to print out the form of the calculation results, to send it by E-mail or to save it.

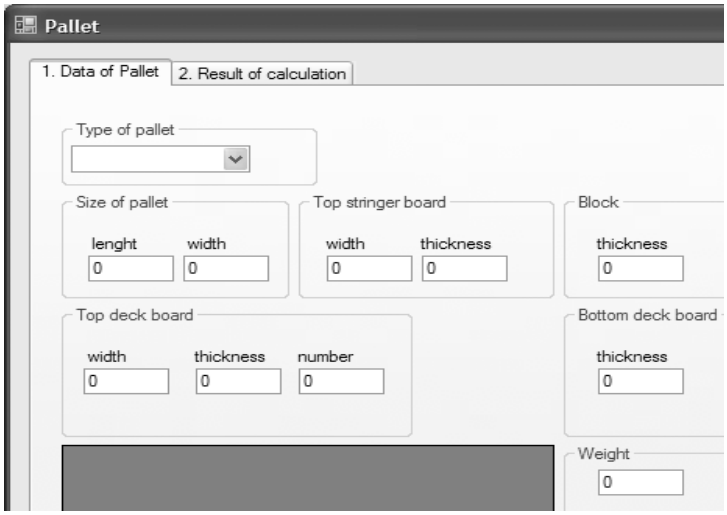

Figure 2. Part of data input.

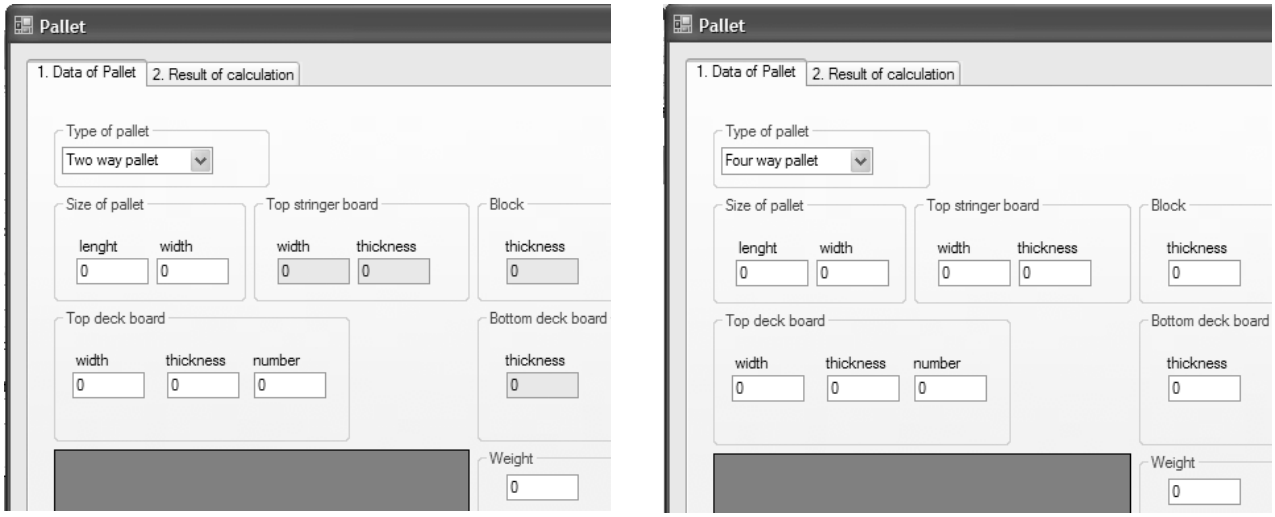

Figure 3. Activated fields for the input of data.

Using the program of calculations, you can easily operate with sizes of the materials and to determine for which loads this pallet is envisaged. It enables to save consumption of the materials as well as to construct a pallet with the required sizes of the cross-section for definite loads.

Results of research of the practical pallet testing

Determining the practical values of the deflection of the pallets was carried out in three ways by loading the pallets and lifting by the lorry loader, or placing at the end support (see Figure 1).

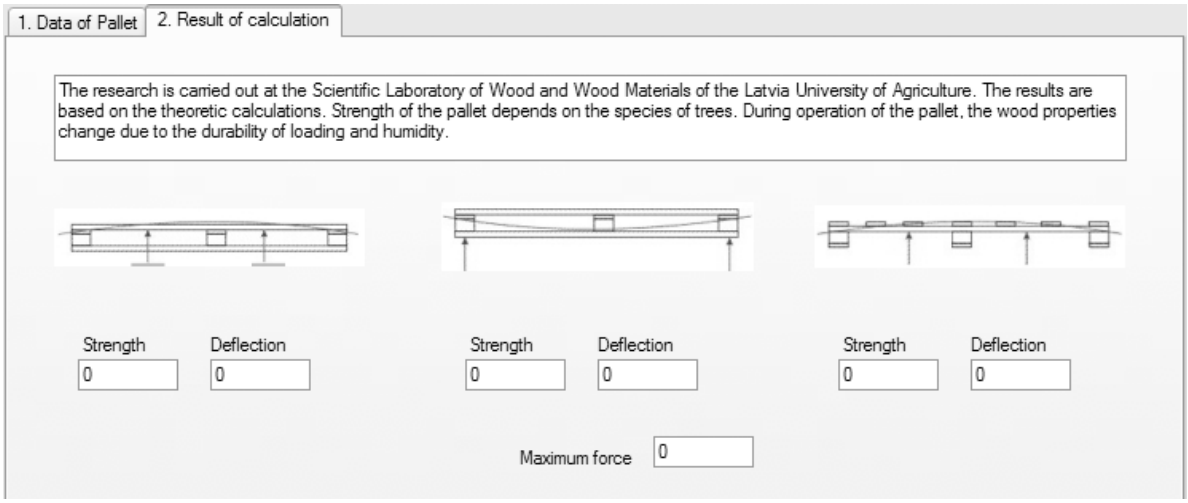

Figure 4. Part of calculation.

Table 2

Practical and theoretical deflection values of the pallets

	Pallet No. 1		Pallet No. 2		Pallet No. 3	
	Practical value, mm	Calculated value, mm	Practical value, mm	Calculated value, mm	Practical value, mm	Calculated value, mm
At the end support	11	9.8	5	9.5	8	11.1
Lifting from the front	3	3.5	2	3.4	2	4
Lifting from the side	1	1.6	1	2.1	1	4.9

Lifting by the lorry loader, the inter-axial distance of forks is as follows: arriving from the front - 650 mm, arriving from the side - 450 mm and loading force - 1.490 kg.

Analyzing the obtained values of deflection it is evident that the theoretically calculated values are averagely on 20...40% higher. It is explained by the fact that for the purpose of simplifying the calculation, resistance of the bottom deck boards and irregularity of the nail connections are not taken into account.

Conclusions

1. The software 'Pallet Testing' (PT) enables to determine the theoretical values of deflection and the maximum load using boards of a definite size.

2. Due to the regularity of the nail connections, which is practically difficult to forecast, the theoretical calculation is simplified by excluding resistance of the bottom deck boards and increasing the calculating resistance.

3. The allowed strain (the normative resistance) in the calculations is increased to 25 $N \cdot mm^{-2}$ due to neglecting calculation of resistance for the bottom deck boards.

4. The practical values of deflection for the pallets are averagely on 20...40% lower than the theoretically calculated ones and the started research is to be continued in order to improve the software.

References

1. ISO 6780 (2003) Flat pallets for intercontinental materials handling - Principal dimensions and tolerances, 2, ISO standards, 13 pp.
2. Lavendelis E., Valdmanis A. (1970) Materiālu pretestība. Mācību līdzeklis (Strength of materials. Study aid). Zvaigzne, Rīga, 456 pp. (in Latvian).
3. Liberty J. (2005) Programming C#, 4th Edition, O'Reily, UK, 666 pp.
4. LVS EN 408 (2003) Timber structures - Structural timber and glued laminated timber - Determination of some physical and mechanical properties, Latvijas valsts standarts, Rīga, 31 pp.
5. MacDonald M. (2005) Visual Basic 2005: A Developer's Notebook, O'Reily, UK, 262 pp.
6. Ozola L. (2001) Koka konstrukciju projektēšana. Slodzes, materiāli, elementu aprēķini, EUROCODE 1, EUROCODE 5 (Design of wooden constructions. Part I. Loads, materials, calculations of elements (EUROCODE 1, EUROCODE 5). I daļa, LLU, Jelgava, 68 pp. (in Latvian).
7. Уголев Б.Н. (2001) Древесиноведение с основами лесного тавроведения (Wood sciences with basic of the forest marketing). 3-е изд, МГУЛ, Москва, 340 с. (in Russian).