Improvement of technology of application of wood as a floor covering

Y Tsapko¹, R Vasylyshyn², O Horbachova³* and O Bondarenko⁴

¹Scientific Research Institute for Binders and Materials, Kyiv National University of Construction and Architecture, Povitroflotskyj ave., 31, Kyiv, Ukraine, 03037 and National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony str., 15, Kyiv, Ukraine, 03041
²National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony str., 15, Kyiv, Ukraine, 03041
³National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony str., 15, Kyiv, Ukraine, 03041
⁴Kyiv National University of Construction and Architecture, Povitroflotskyj ave., 31, Kyiv, Ukraine, 03037

*E-mail: gorbachova.sasha@ukr.net

Abstract. The analysis of wood flooring has been made and it has been found that the manufacture of wood flooring poses certain difficulties in ensuring resistance to destruction. Thermally modified wood is one of the promising uses of flooring. Therefore, knowledge of the physico-mechanical features of wood composites, their quality indicators, adhesion with organic adhesives, allows to make a choice taking into account economic indicators, duration and safety of application. Experimental studies have found out that a floor covering with an upper layer of thermally modified oak wood is less resistant to abrasion. The additional moisture effect showed a better result for the thermally modified oak samples than for the ash and oak samples. The test pieces with an upper layer of thermally modified oak are found to have the lowest measure of power. The results of the research will enable the further development of new composites of thermally modified wood and the conditions under which they are operated at different sites.

1. Introduction

Today, wood is a major floor covering. Wooden floors have high wear resistance, durability, impact resistance, low heat conductivity and noiseless while walking. The main species for floor production are hard woods like: oak, beech, maple, ash [1, 2].

One of the main disadvantages of the use of wooden floor is its deterioration and knowledge of the physical and mechanical properties of such construction products, their quality indicators, allowing for the choice taking into account economic indicators, duration and safety of application, environmental aspects, etc. [3-6].

Therefore, the development of technological measures for the manufacture of wooden flooring and the research on the impact on the strength of different flooring of different wood species is an unresolved component of the sustainability of composite products and determines the need for research.

2. Analysis of recent research and publications

In the use of wooden floors it is assumed that the characteristics of application are significantly influenced by the conditions [7-9]. In this connection, a study has been carried out and it has been established that environmental certification and guarantee, especially in relation to the production of wood-based composites, have been the most important factor in determining preferences. The focus was on estimation methods of effects on wood characteristics. However, it is not specified the
influence of differences among different wood species, as well as the wide variety of ways of composites creation.

During operation, the parquet board shall be exposed to various external factors affecting the stability of its shape [10], these include temperature, humidity and the load which the parquet board gets during operation. It has been established that each of these factors affects the stability of the shape differently, but that a long-term or joint action can alter its features or even destroy the parquet board. However, it is not identified how the exertion changes when the rocks in the composition article change according to the temperature change.

Despite increased biological stability and changes in size stability at temperature fluctuations which calls for durability tests that are the most sensitive to decomposition, but neither strength tests nor fungus identification which is responsible for decomposition are not included in the above-ground strength standards for field tests [11]. However, the necessary methods for characterizing the change in wood quality in terms of improved target surface properties are not specified either.

Changes caused by bacterial action that may affect surface quality have been measured and compared to the test samples, as bacterial destruction is closely related to surface wear [12]. After wood treatment, surface properties and aesthetic changes were assessed; and the performance of the coverings was evaluated. The antiseptic covering retains resistance to wood destruction, while without antiseptic increases surface destruction. However, there are no methods for estimating bacterial surface degradation.

There are a number of test methods simulating loads on wooden floors [13], where adhesion, impact strength, elasticity, wear resistance and resistance to various liquids are all significant indicators of the quality of wooden floors. However, some of them do not specify minimum requirements or reference values for the specific technical properties of the wood surface.

The quality of oak and chestnut wood for floor coverings has already been confirmed [14] and it has been established that shrinkage and swelling, favourable to both species of wood, are encouraging the slight swelling of chestnut in the tangential direction; the hardness of oak was higher due to higher density. However, the characteristics aren’t specified when making composite products from them.

Many wood species are used as flooring, but their characteristics may vary greatly depending on the properties of the wood and the type of application [15]. Industrial wooden floors have been subjected to tests on the falling ball, rolled loads, ground dents through small loads, and static and dynamic friction. In accordance with the characteristics of the wooden flooring, were established the resistant classes in the simulation tests. However, it is not specified how wood species are graded according to each class.

The study in [16] carried out dynamic hardness tests on solid and engineering wooden floors. The results showed similar behaviour towards traditional hardwood species applied to wooden floors, and this may be a promising growth in flooring industry. However, the use of pulp wood remains unresolved.

Preliminary tests were carried out to determine the geometric stabilization of wooden floor samples [17-19]. As a result, it has been determined that the flow of channels for hardwood parquet is no better for improving geometric stability under different climatic conditions. However, the method of estimating the surface after wood treatment is not specified.

The difference in adhesive properties through the different chemical composition of the fibre surface has been evaluated and it has been established that it is replaced by the penetration of adhesive into the volumetric fibre of the wood [20]. These results show more lignin or hydrophobic extractive substances on the fiber surface. With regard to the characteristics of adhesion, these results indicate the formation of a less polar surface of thermally modified fibres. However, the role of adhesive compositions on the properties of wood composites is not disclosed.

Thus, it has been established from literary sources that the application of wooden floors under different climatic conditions requires appropriate research to counteract the destruction. This suggests that a study to determine the parameters that ensure its durability would be useful. Research in this
area is therefore an unfinished part of the sustainability of building structures and has necessitated researching.

3. The purpose of this work
The purpose of this work is to study the efficiency of wooden flooring for wood products and to substantiate its strength in operation.

4. Materials and methods of research
The physical-mechanical and operational properties of the parquet board were investigated in order to determine the prospects for the production of floor coverings depending on the conditions of use. The first group of samples consisted of two layers of ash wood and an upper layer of thermally modified oak wood; the second group consisted of a base of water-bearing plywood, a middle layer of XDF from the outside of ash wood; the third group consisted of pine veneer as a lower layer, in the middle of XDF, the wood of oak as the top layer is Figure 1.

![Figure 1. Test samples of parquet board: a – top layer from thermally modified oak wood; b – top layer from ash wood; c – top layer from oak wood.](image)

The durability of a material is defined as the wear on the top layer of a parquet board when used in the operation of friction forces. The essence of the method is to determine the loss of mass when the surface of the upper layer is abraded by an abrasive material with the specified load on the sample. The studies were carried out on samples measuring 50x150x14 mm, which were pre-stored 72 h in a room with an air temperature of 23±2 °C and relative humidity of 65%. Grinding material with a grain capacity of 240, the speed of movement of 1.55 m/min, the time of grinding 2 min, the load on the sample 2 kgf. At the end of the abrasion, the sample was weighted to an accuracy of 0.01 g and determined the abrasion by the formula:

\[ t = h \cdot \frac{m_1 - m_2}{m_1} \]  

(1)

where \( h \) – is the height of the test sample, mm; \( m_1 \) – is the mass of the sample before the test, r; \( m_2 \) – is the mass of the sample after the test, r.

During the operation of the flooring the contact with water is possible, so it is worth investigating the resistance of the upper layer to the effects of moisture. The moisture absorption experience was carried out in a sodium-saturated desiccator on the three parquet board types described above, measuring 40x50x14 mm. The test samples shall be preconditioned at a temperature of 23±2 °C and a relative humidity of 65% for three days for stabilization. The test samples were weighed with a deviation of not more than 0.01 g and placed in the desiccator with a lateral surface on the insert so that they do not touch each other and the walls of the desiccator. The soak was carried out in the air at a temperature of 20±2 °C. The samples were periodically weighed with a deviation of not more than 0.01 g the first weighing was carried out 24 hours after the sample was placed in the desiccator, followed by 2, 3, 6, 9, 13, 20 days later.
In the study of the glue compound, samples of three types of parquet board with dimensions of 40x50x14 mm were used after stabilization within three days. The essence of the strength limit method is to determine the breaking load vertically down at the glue junction (Figure 2).

![Figure 2. Load test for the measure of power.](image)

The sample was loaded continuously at the loading speed of the test vehicle head $0.60 \pm 0.15$ mm/min. The tests continued until the fracture of the sample and determined the measure of power by the formula:

$$\sigma = \frac{P}{b \cdot l}$$  \hspace{1cm} (2)

where $P$ – is the destructive load, H; $b$ – is the width of the glue, m; $l$ – is the length of the glue, m.

The result was rounded to 0.1 MPa. The surface fracture rate was observed during the tests.

5. **Research results**

In Figure 3-5 show the abrasion results. In determining the resistance to abrasion, samples with an upper layer of oak wood showed the best results – less traces were left on them and on the polished skin as well (Figure 3). This suggests that this type of floor can be used in areas with large traffic.

![Figure 3. Results of the assessment of the abrasion resistance of the top layers of oak wood parquet board.](image)

Under the same experience conditions, the grit paper removed a slightly larger layer of material – 0.2 mm. There are already visible friction marks in the form of rings and rubs in Figure 4. The samples with an upper layer of thermally modified oak did not perform as well as the previous ones (Figure 5). During grinding, black dust with a specific odour was released. Friction marks are clearly visible. The thickness of the layer removed is 0.36 mm.

After weighing the samples, it is established that the floor covering with an upper layer of thermally modified oak wood is less resistant to abrasion.

As a result of experience, it has been established that the most weight was lost in the sample with the upper layer of thermally modified wood – 1.01 g. The abrasion rate was 0.30. The most marks from the grit paper remain on the surface of the samples. The least weight – 0.38 g – has lost the
sample with surface of oak, the abrasion rate is 0.07. There were less grinding marks on the ash wood sample.

**Figure 4.** Results of the assessment of the abrasion resistance of a hardwood parquet board with top layers of ash wood.

**Figure 5.** Results of the assessment of the abrasion resistance of the different top layers of parquet board with thermally modified oak.

Samples with an upper layer of ash wood showed a slightly worse result (Table 1).

**Table 1.** Results of the assessment of abrasion resistance of different materials.

| Specimen (top layer)     | Specimen thickness, mm | Specimen mass, g before abrasion | Specimen mass, g after abrasion | Mass loss, g | Abrasion rate, t | Visual assessment |
|--------------------------|------------------------|----------------------------------|---------------------------------|-------------|-----------------|------------------|
| Thermally modified oak   | 14.10                  | 46.9                             | 45.89                           | 1.01        | 0.30            |                  |
| Ash                      | 14.05                  | 73.57                            | 73.02                           | 0.55        | 0.11            |                  |
| Oak                      | 14.00                  | 75.86                            | 75.48                           | 0.38        | 0.07            |                  |

As a result of the experience with the determination of moisture absorption, the samples were found to have absorbed most of the moisture at the beginning of the experiment (Table 2).
Table 2. Change in mass of the floorboard samples in the wet environment*.

| Specimen (top layer) | Change in mass of samples during keeping in a humid environment, g | Mass of absorbed moisture, g |
|----------------------|---------------------------------------------------------------|-----------------------------|
|                      | Duration of keeping in the environment with high humidity, days |                             |
|                      | 0     | 1     | 2     | 3     | 6     | 9     | 13    | 20    |       |
| Thermally modified oak | 15.40 | 17.62 | 17.95 | 18.50 | 19.99 | 21.99 | 23.57 | 24.54 | 9.14  |
| Ash                  | 19.21 | 21.82 | 23.60 | 24.23 | 26.42 | 27.90 | 29.55 | 31.37 | 12.15 |
| Oak                  | 23.87 | 26.54 | 27.21 | 28.29 | 30.60 | 32.93 | 35.45 | 37.80 | 13.93 |

*Note. Specimen initial moisture content 8 %

The first group of samples absorbed the least moisture in 24 hours – 2.22 g, and the most with the top layer of oak – 2.66 g. The difference is that the percentage is 19.17%, which is 2% less than the other two groups.

In 20 days, the humidity was determined to have changed by 71.28% in samples with the top covering of ash wood. The samples with the covering of thermally modified oak performed better, the humidity increased by 65.7%. These samples also showed high size and shape resistance, unlike the others (Figure 6 a). The samples with the top layer of oak wood have buckled up (Figure 6 b) and the samples with the wood ash covering have peeled off in Figure 6 c.

![Figure 6](image)

**Figure 6.** Test samples of parquet board after soaking in a moist environment: a – top layer with thermo-modified oak wood; b – top layer of ash wood; c – top layer of oak wood.

Figure 7 shows the strength of the adhesive connection between the different groups of parquet board samples.

![Figure 7](image)

**Figure 7.** Measure of power of adhesive connections of different groups of parquet board samples.
Samples with an upper layer of thermally modified oak – 3557.1 MPa (Figure 7) have been determined to have the lowest strength.

A slightly better result in samples with an upper layer of ash – 4701.4 MPa; the hardwood parquet board with wood oak – 6458.1 MPa – showed the greatest strength. Similar samples were also examined to test the adhesive strength of the adhesive compound after being held in water. All the samples showed the twice worst result.

6. Conclusions
Thus, experimental studies have shown that floor covering with an upper layer of thermally modified oak wood is less resistant to abrasion. The additional moisture effect showed a better result for thermally modified oak-coated samples than for ash and oak samples. The test pieces with an upper layer of thermally modified oak are found to have the lowest strength. The results of the research will enable the further development of new composites and their operating conditions at different facilities.

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Acknowledgements
Authors express their gratitude to the Ministry of Education and Science of Ukraine for financial support of the research, that was performed in the framework of budget funding No. 0121U001007, as well as for the development of the theme of research according to the program of scientific cooperation COST Action FP 1407 "Understanding the modification of wood through an integrated scientific and environmental approach" of the European Union’s framework program HORIZON 2020.