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THE EFFECT OF WOOD VENEER TYPE ON THE REDUCTION OF SOUND TRANSMISSION BETWEEN NOISE-PRODUCING INTERIOR SPACES IN BUILDINGS

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Highlights

- The effect of wood veneer materials on sound transmission between spaces was investigated.
- The sound transmission amounts of different wood species were measured with the help of a special device.
- An evaluation was made by comparing the sound transmission amounts of wood veneer types.

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ABSTRACT: In order to provide auditory comfort indoors, it is necessary to prevent noise generation and transmission. In this respect, coating materials are essential in reducing sound transmission between interior spaces in noise-generating buildings. Wood is one of the most widely used materials for interior walls and floor coverings. Wood cladding materials can reduce noise transmission. However, the wide variety of types of wood cladding material will create differences in its contribution to noise insulation in this sense. In this direction, the study aimed to investigate the noise transmission properties of different types of wood veneer materials. This study measured the sound transmission amounts of different wood veneer materials with a particular device. This apparatus was used to determine the amount of sound transmitted from the inner face of the veneer material to the outer face of the veneer material of the noise source in an isolated environment with other surfaces touching only the inner face of the veneer material. The measurements were made with the help of this box so that the sound transmission data of different types of wood veneer materials with the same environment and noise source were evaluated using the comparative analysis method. For the study, 24 different wood veneer materials were tested. As a result of the research, it was concluded that the wood cladding material effectively reduces the amount of sound transmission and that there is variability in sound transmission performance depending on the wood species.

Keywords: *Auditory Comfort, Decibel, Noise, Sound Transmission Measurement, Wood Veneer Material*

1. INTRODUCTION

Spaces should provide comfort conditions while meeting the functional needs of the user. Auditory comfort, one of these features, is the condition that the acoustic environment characteristics of the spaces are suitable for the user [1];noise is defined as unwanted sounds that disturb the user [2]. In this respect, attention should be paid to preventing the formation and transmission of noise in space design. Noise can be prevented by measures taken at the source, receiver and environment [2]. The indoor environmental quality of spaces impacts on health, comfort, productivity, perception, mental and physical performances [3, 4]. Acoustic properties also have significant effects on indoor ambient comfort [3]. Acoustic, thermal and lighting conditions are the most influential factors on indoor comfort [5]. In addition, exposure to high noise levels negatively affects focus, productivity, communication and learning skills, psychological, health and general well-being [6-8].

Since covering materials are effective in sound transmission and noise transmission, the intended use of the space should be taken into considered when choosing materials [9]. The shape of the space, acoustic properties of the materials and objects in the space are practical on sound transmission. For example, porous materials such as carpets, drapery and upholstery absorb high frequencies well, while wood panels absorb low frequencies. In concert halls, the use of wood in combination with textiles for flooring, seating, reflective panels and wall coverings provides both aesthetics and optimization of the sound field, reverberation time and brightness [10].

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1.1. Wood as a Cladding Material and Sound Transmission

Wood was one of the first building materials that people used to meet their shelter needs and is still used today. In this respect, with the development of wood, which has been used for a long time, its usage area has also diversified considerably. Wood was one of the first building materials that people used to meet their shelter needs and is still used today. In this respect, with the development of wood, which has been used for a long time, its usage area has also diversified considerably.

Due to the good sound absorbing properties of wood, it is preferred as a coating material. Its fibrous structure, dampens impact sounds and prevents sound transmission and echoing [11].

In wooden materials, sound can both spread and suffocate. In this respect, wood material shows a superior feature compared to other materials [12]. The speed of sound in a structural material varies according to flexibility and density. In wood, the speed of sound also varies according to the grain direction, as the transverse modulus of elasticity is much less than the longitudinal value. In wood, the speed of sound along the grain is about one-fifth to one-third of the longitudinal value [13].

Studies have shown that wood materials provide sound insulation thanks to their ability to absorb sound [14] and their sound absorption values depend on the type of wood used [15, 16] the inner layer structure of the wood material [12], the perforated structure [17], heat treatment [18], and the type of varnish used [19].

1.2. Industrial Wood Species That Can Be Used As Cladding Materials

Industrial wood is obtained by combining wood pieces, boards, timber, chips, and fibers with different techniques and binding agents to strengthen the properties of wood and add homogeneous properties [20]. Industrial wood materials provide various features that solid wood cannot provide and provide ease of use (Figure 1) [21].

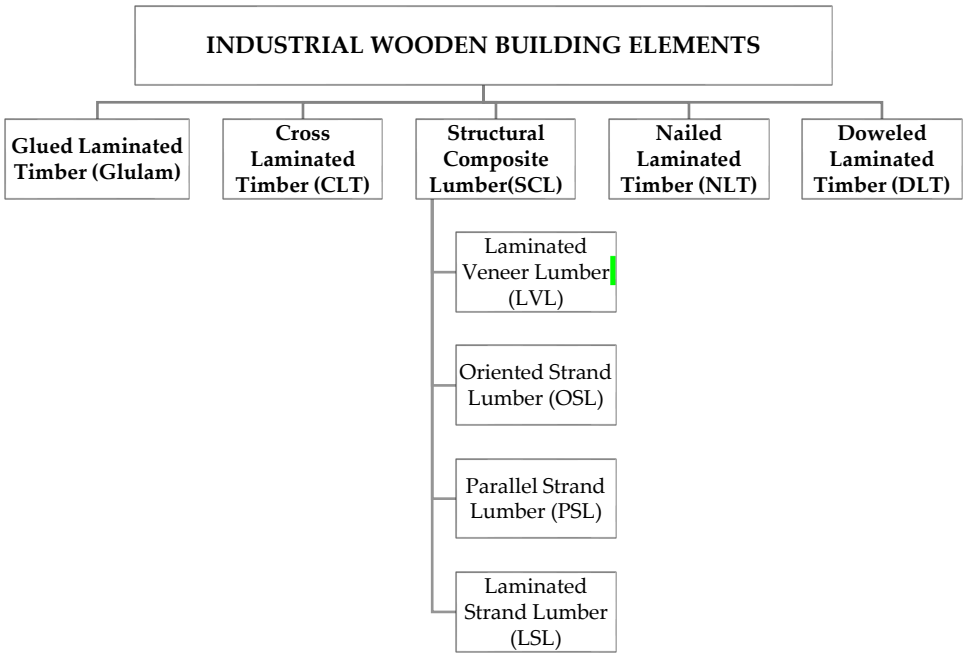


Figure 1. Classification of Industrial Wooden Building Elements [21]

Wood materials used in construction are generally divided into solid wood and composite wood. Solid wood is the state of the tree that has not undergone any treatment other than drying and shaping after cutting. Composites are materials formed by combining two or more materials. Various processes are carried out in these materials to increase the strength and functionality of wood according to environmental conditions. Wood composites are obtained by combining wood-wood or wood with other

materials. The classification of wood composites that differ in terms of their properties is given in Table 1 [22].

Table 1. Classes of wood composite materials

WOOD COMPOSITE CLASSES				
Board Products	**Structural Composites**	**Mechanically Laminated Components**	**Molded Products**	**Wood-Non-Wood Product Composites**
• Plywood • Contrablas • Particleboards [Particleboard, Waferboard, Flakeboard, OSB (Oriented Strand Board) • Fibreboards [MDF (Medium Density Fiber Board), HDF (High-Density Fibre Board), Insulation Board]	• Structural Composite Timbers [Parallel strand lumber (PSL), Laminated Strand Lumber (LSL), Oriented Strand Lumber (OSL), Laminated Veneer Lumber (LVL), Glued Laminated Timber (GLULAM)] • Structural Board Products [Structural Plywood, Structural Flakeboards (Waferboard, OSB)] • Wooden I beams • COM-PLY timbers*	• Elements obtained by joining timbers with nails, screws, etc.	• Products where fibre or particle boards are produced in a form suitable for the place of use	• Composites using in organic materials as binders (Plaster Boards, Magnesium Cement Boards, Portland Cement Boards)

**A product obtained by compressing a center section of oriented or randomly positioned chips between at least two veneer boards. It was developed by the USDA Forest Service (Forestry Division of the United States Department of Agriculture) in the 1970s.*

The properties of wood composites obtained with inorganic binders differ according to the binder used. Gypsum, magnesium cement and Portland cement are used as binders. The most preferred type is Portland cement composites, which also provide sound insulation. Since it is resistant to moisture, it is used indoors and outdoors. Gypsum binder wood composites, also called dry wall, are generally used in interior wall and ceiling construction and are not resistant to moisture [23].

The so-called thermoplastics are polypropylene, polystyrene, vinyl, low-high density polyethylene. Wood flour is used for filling in thermoplastic composites. Depending on the amount of thermoplastic, there are composites with high and low thermoplastic content. Thermoplastics are also used in nonwoven textile type composites. Long fibers obtained from jute, hemp or synthetic thermoplastics are used in their production [23].

1.3. Psychological Effect of Wood on the User

Wood materials have a different perceptual effect on people than other materials because they are natural materials consisting of living organisms. Studies on this subject have shown that wood is warm, friendly, pleasant and preferred in the environment compared to other materials[24-26] and the positive effects of the use of natural wood and its smell have been shown to reduce fatigue and depression [27, 28].

1.4. Wood Production and Recycling

Compression and densification processes are carried out in the wood production stages to improve the physical and mechanical properties of wood. This process increases its smoothness, moisture resistance and hardness. However, as a result of the heat treatment applied to prevent stretching, color change occurs and weight, mechanical, gloss and smoothness properties decrease [29].

Wood is a valuable material for being a recyclable and reusable material. In this respect, the wastes

generated while producing of wood materials are also utilized again in material production processes [30, 31]. In addition, wood is an ecological material that offers the opportunity to create different materials by combining with other waste materials [32].

Today, with the deterioration of the natural ecosystem and global warming, the tendency towards natural materials, ecological and sustainable design has increased. Accordingly, the use of wood, which is environmentally sensitive, renewable and has low embodied carbon energy [33], is increasing daily. In order to meet the increasing demand, industrial afforestation is carried out by growing needle and broad-leaved tree species, also called industrial plantations, which are generally fast-growing [34].

2.MATERIAL AND METHODS

The study used 24 wood and wood-containing building materials to evaluate the sound transmission amounts. Iroko, tar, sapelli (mahogany), red pine (heat treated), black pine, meranti, yellow pine, red pine as laminate parquet; red pine and fir as solid blocks; MDF separator, double-sided veneered MDF, double-sided veneered perforated MDF, MDF with out veneer, double-sided veneered chipboard, wood-like textured MDF veneer, plywood, laminate parquet with 2 different appearances, pool edge cladding with grooved bottom, MDF wall cladding, thin MDF without veneer, thin rose veneer and thin beech veneer were used as experimental materials in the research. In addition, the amount of sound passing through the combination of MDF with out veneer and MDF separator, thin rose and thin beech veneers were tested separately. The materials subjected to the research were tested with the thicknesses normally used in applications, while their widths and lengths were prepared to fit into the 20x20 cm chamber created for the material in the sound measurement box. The thicknesses of the building materials used were measured and recorded with an electronic caliper with a precision of 0.01 mm.

A specially prepared insulated noise measurement box, as shown in Figure 2, was used in the measurements and the sound permeability of the materials was evaluated by the comparison method. The measurements were made and recorded on the same day and time in the same environment.

Figure 2. Specially Prepared Insulated Sound Transmission Measurement Box

The test box used to measure the sound transmission of building materials consists of a 60x60x60 cm bottom part and a 15 cm high cover part. The outer part of the box is made of 8mm fiberboard, the inner part is insulated with rock wool and the lid is insulated with insulation foam. With the help of a noise generating sound device and sound measuring devices, the amount of sound passing through the materials was evaluated. Thanks to the glass section on the lid of the device, the values shown on the sound meter were recorded non-contact. A schematic representation of the noise measurement box is shown in Figure 3.

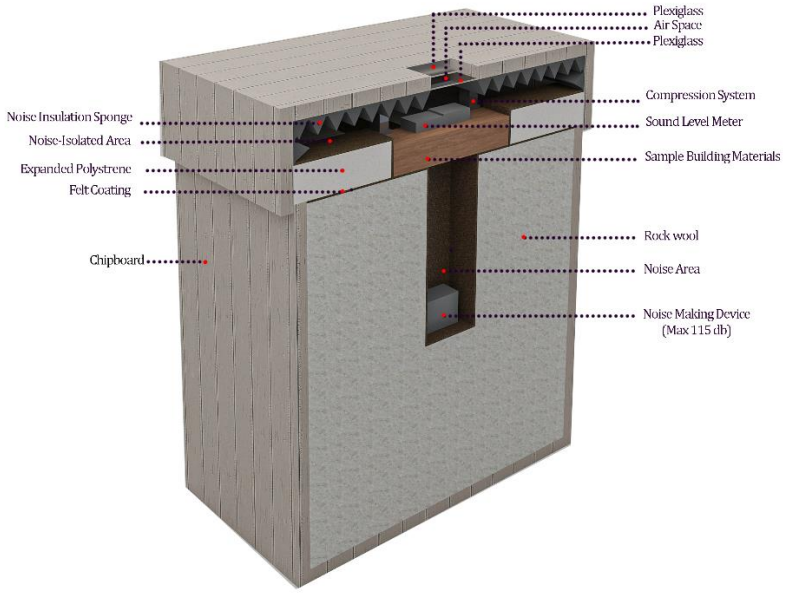


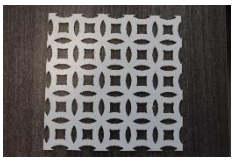
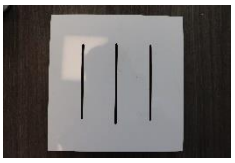
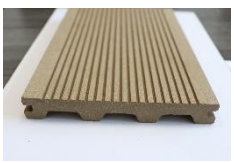
Figure 3. Schematic Material Display

3. RESULTS AND DISCUSSION

In the prepared sound measurement box, the amount of sound transmission was recorded as 103.00 dB in the empty state without any material. Then, readings were taken for each material and the amount of sound transmitted to the upper surface of the material was determined. According to this process, the thickness of the wood-based coating materials tested, and the sound transmission amounts obtained as a result of the experiment are shown in Table 2.

Table 2. Utilization Thicknesses and Sound Transmission Amounts of Building Materials

Building Material	Material Utilization Thickness (mm)	Sound Transmission Amount (dB)	Building Material	Material Utilization Thickness (mm)	Sound Transmission Amount (dB)
 **Iroko**	17,85	61,80	 **Tar**	17,90	62,70
 **Sapelli (Mahogany)**	17,75	57,60	 **RedPine (heat treated)**	17,50	59,90
 **Black Pine**	16,90	61,80	 **Meranti**	18,00	65,40

 **YellowPine**	17,85	62,90	 **RedPine**	16,93	61,50
 **Red Pine Solid Block**	16,55	58,20	 **Fir Solid Block**	16,50	61,80
 **MDF Separator**	2,85	92,40	 **Double-Sided Veneered MDF**	17,93	53,90
 **Double-Sided Veneered Perforated MDF**	18,15	81,30	 **Double-Sided Veneered Chipboard**	18,20	56,00
 **MDF Without Veneer**	18,25	58,00	 **Wood-Like Textured MDF Veneer**	3,50	65,00
 **LaminantParquet(A)**	7,85	58,00	 **Laminant Parquet (B)**	7,75	56,00
 **Pool Edge Cladding With Grooved Bottom**	19,30 / 11,10	67,00	 **MDF Wall Cladding**	13,80	73,00

 **Plywood**	6,30	62,00	 **Thin MDF Without Veneer**	5,95	59,00
 **Thin Rose Surface Veneer**	0,60	73,90	 **Thin Beech Surface Veneer**	0,65	70,80

As a result of the measurements obtained, the wood veneer material with the lowest sound transmission amount was MDF with double-sided veneer. In constrast the veneer material with the highest sound transmission amount was MDF separator. In addition, measurements were also made on uncoated MDF, thin rose and beech surface coatings and the use of MDF separators. As a result of the measurements;

- MDF with out veneer + Thin Beech Surface Veneer with a measurement of 51.30 dB,
- MDF with out veneer + Thin Rose Surface Veneer with 53,70 dB and,
- MDF with out veneer + MDF Separator with 51.40 dB recorded.

Thus, since the sound transmission amount measured from the thin beech surface coating with MDF with out veneer was 51.30 dB, it was the material that prevented the noise the most by producing better results than the double-sided veneered MDFbuilding material with the lowest sound transmission amount with 53.90 dB. In addition, in the sound measurements, the measurement made with MDF with out veneer and MDF separator placed on one side was lower than the measurement made with double-sided coated MDF.

As a result of the sound measurements made in the study, it was determined that alder has better sound retention properties compared to fir. In addition, it was observed that double-sided veneered MDF passes less sound compared to double-sided veneered chipboards.

In the sound measurements made with double-sided veneered MDFs, it was observed that the sound transmission amount of perforated MDF increased significantly.

Among the iroko, tar, sapelli (mahogany), heat-treated red pine, black pine, meranti, yellow pine, red pine materials used as laminate parquet, sapelli (mahogany) had the lowest sound transmission amount in the sound measurement made in the study.

In sound measurements with thin surface veneers, Beech showed less sound transmission compared to Rose material.

Although the wood-like textured MDF cladding material is a thin, in the sound measurements made, it transmitted a lower amount of sound than the thicker meranti, pool edge cladding with grooved bottom, MDF wall cladding and double-sided veneered perforated MDF materials.

Altunok, in their 2012 study, stated that yellow pine panels were less sound permeable than iroko in sound measurements, However in the comparison measurements made in this study, the amount of sound permeability of iroko was found to be less than that of yellow pine [15].

In Ayan's doctoral thesis study in 2012, it was stated that the sound absorption property of heat-treated wood increased in the sound measurements made, and in our study, the sound transmission amount of heat-treated red pine was lower compared to red pine, and similar results were obtained [18].

Çavuş stated that black pine has less sound transmission properties than yellow pine due to measurements within the scope of his study in 2020 [35]. It is seen that a similar result was reached with

this study.

4. CONCLUSIONS

In the study, sound transmission values of wood veneer materials were measured using the same environment and noise source, and the following results were obtained by comparative analysis in terms of sound transmission potentials. According to this:

- The contribution of wood materials in sound transmission in the interior varies depending on the type of wood,
- In the sound transmission measurements, sapelli (mahogany) was the slightest sound transmitting among the laminate parquets. According to this result, sapelli (mahogany) can be preferred as laminate parquet in interior spaces because it also contributes to noise control,
- The heat-treated material shows a better sound transmission performance compared to its normal state,
- Especially in noisy interiors, double-sided veneered MDF material can be preferred instead of double-sided veneered chipboard as it prevents sound transmission more,
- Separators, which are generally used to divide spaces into different areas, also have an effect on sound transmission, and in this respect, especially in multi-use areas such as open office areas, the use of separators will provide auditory comfort,
- Among all the measurements made, it was concluded that the least sound-permeable coating material was MDF with beech veneer, and that it may even be the best wood veneer material to be used to prevent sound transmission between interior spaces of noise-producing structures by absorbing almost half of the sound produced by the sound generating device.

The study showed that noise permeability can be reduced according to the type of wood coating materials.

The fact that similar findings were obtained in this study and other studies in the literature reveals that the study method is appropriate. In this direction, it is recommended that new studies be conducted with different coating materials. Reducing the noise with the studies to be carried out will ensure the protection of the auditory comfort environment in other spaces.

Declaration of Ethical Standards

The authors declare that they have carried out this completely original study by adhering to all ethical rules including authorship, citation and data reporting.

Credit Authorship Contribution Statement

E. N. ERZURUM SONUÇ: Methodology, Conceptualization, Resources, Investigation, Writing.

M. DERELİ: Methodology, Conceptualization, Resources, Investigation, Writing -review & editing, Supervision.

Declaration of Competing Interest

The authors declared that they have no conflict of interest.

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Data Availability

Data supporting the findings of this study can be obtained from the corresponding author with reasonable requests to assist in scientific studies.

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