

ANTIQUe WOODEN FLOOR REUSE POSSIBILITIES IN VIEW OF THEIR USAGE PROPERTIES PRESERVATION



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Palace of Versailles, the Hall of Mirrors, 1679
Jules Hardoium-Mansart and Charles Le Brun (1647-1708)



*Łancut Castle parquet



2. AIM and SCOPE of RESEARCH

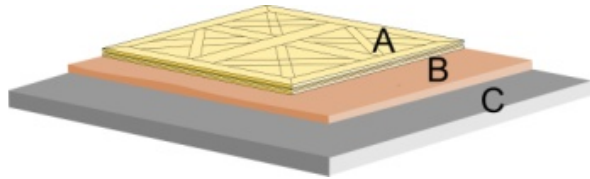
- The aim of this research consists in **proposing criteria** to assess antique, decorative wooden floors and decide on the **possibility of their further usage and conservation methods**.
- The research of antique floors covered 76 rooms in 21 castles, hunting lodges and manor houses in South-Eastern Poland, dated from the 19th century.
- We paid particular attention to the stage of diagnostics.
- It was paramount to closely follow the currently standards and guidelines.
- The conservation and restoration activities had to be: **necessary, minimum** and **reversible**, and the **efficiency** of the used techniques had to be proven.
- The plan of conservation interventions in wooden structures was preceded by a scientific study and moreover, mathematical tests and models were indispensable.

3. METHODOLOGY

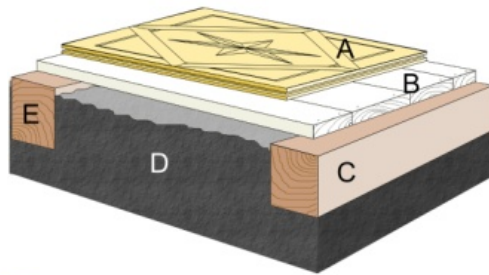
- The production of parquet materials is regulated by CPR (EU) 305/2011 that requires the application of **European harmonised standards**.
- The tests of **wood resistance properties** were carried out in line with the binding standards: **bending strength and elasticity modulus** tests in line with EN 408, **hardness** - EN 1534, **resistance to abrasion** with the Taber method - EN ISO 5470-1, **resistance to scratching** on the basis of EN 438-2:2005.
- The capacity to transfer the structure's own, static loads and live loads was assessed through **numerical calculations** in Autodesk Inventor Professional software.
- The function of each structural layer of the floor was determined by comparing the elasticity (**transfer of dynamic loads** by shock absorption-force reduction in accordance with the EN 14808 and 14809 standards), while the floor's resistance to dynamic loads caused by a soft body impact was tested in line with the EN 1195 standard.
- The role of parquet panel designs in the stability of their dimensions and the distribution of stresses were analysed by **modeling the swelling process** in the SolidWorks Simulation 2011 software.
- **Longitudinal curvature** was determined in accordance and **right angles** in line with EN 13647.
- The analysis of the **influence of woodwork joints** between panel elements on the character of their work and the loading degree were carried out with the use of a series of numerical analyses performed in the Autodesk Inventor Professional.
- Moreover, we tested the **moisture equivalent** and **wetting curves** through mass measurements, **ergosterol** with the use of the Seitz method (1979), and carried out quantitative and qualitative **chemical tests** (the degree of cellulose polymerization with the help of SEC -Size Exclusion Chromatography analysis).

4. TEST RESULTS

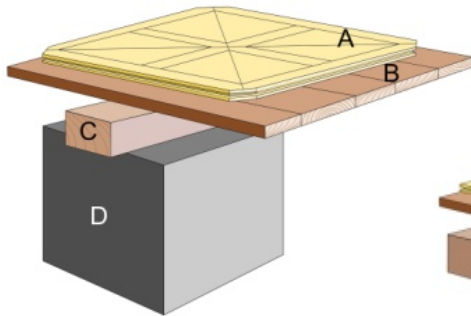
4.1 Construction Solutions in Antique Floors



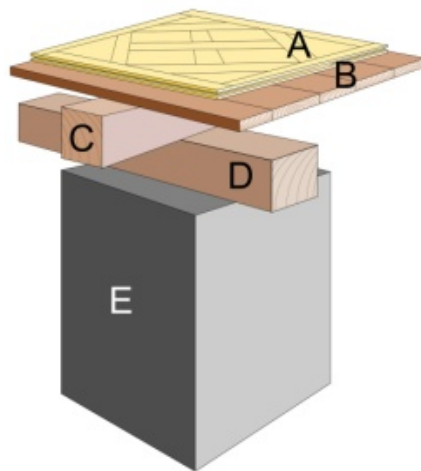
Chapel in the Łańcut Castle
(a: A- panel. B- sand, C- concrete)



Ball Room in the Łańcut Castle
(b: A – panel, B – boarding, C - ceiling beams,
D – sand)



Przewrotne Manor House
(c: A – panel, B – boarding, C - ceiling beams,
D – bricked post)



Falejówka Manor House
(d: A – panel, B – boarding, C -
ceiling beams, D – binding joist,
E -bricked post)

4. TEST RESULTS

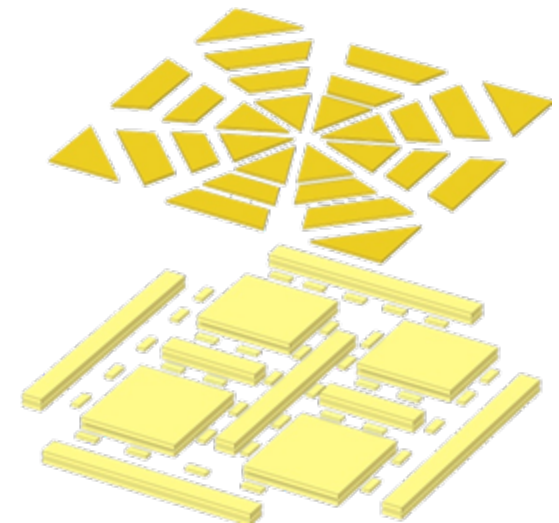
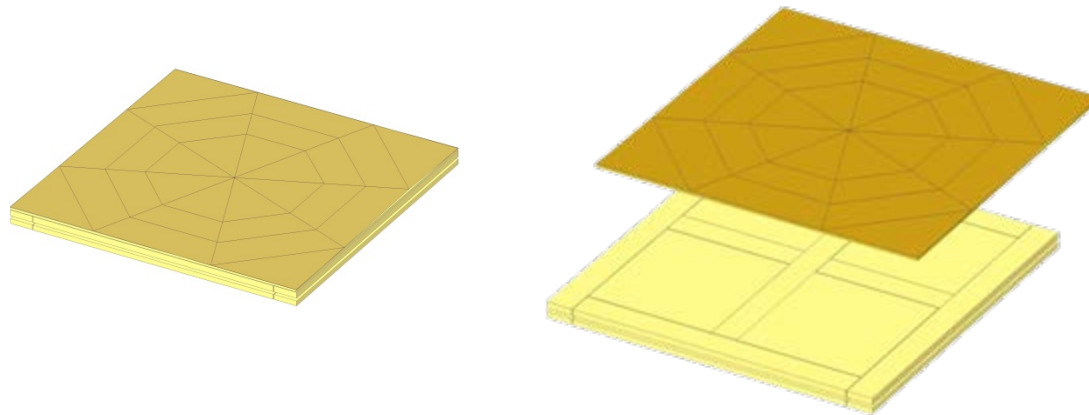
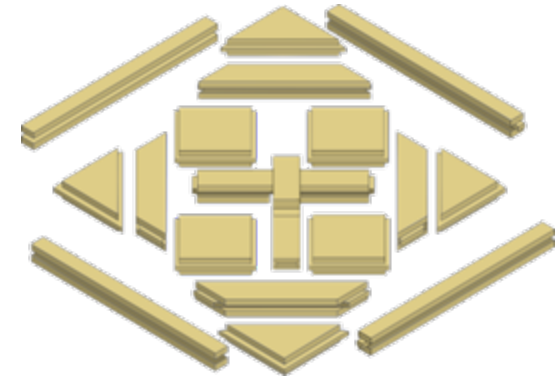
4.1 Construction Solutions in Antique Floors

Uneven bottom surface of the panel and signs of mechanical and manual processing (with an axe or a plane) of the parquet's bottom side

Differences in thickness between the frame and the elements inside it may reach up to 20mm and serve the purpose of economising the material

The internal elements are suspended on the frame, on joints and collapse

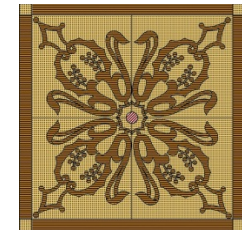
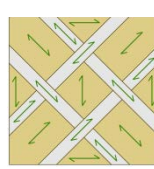
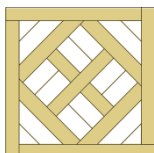
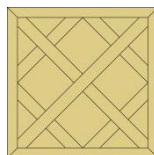
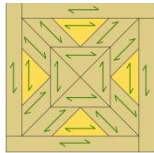
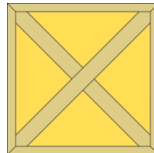
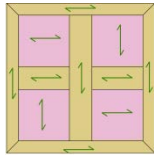
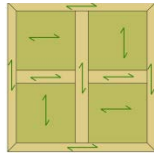
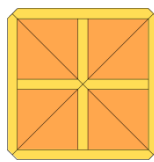
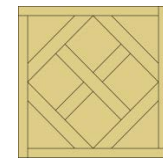
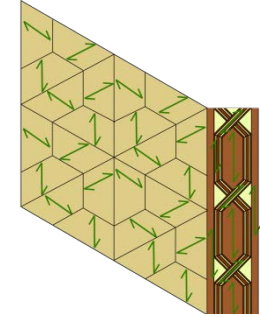
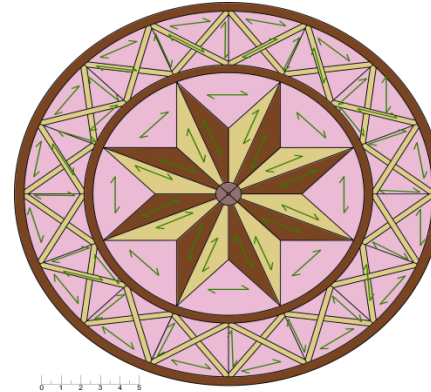
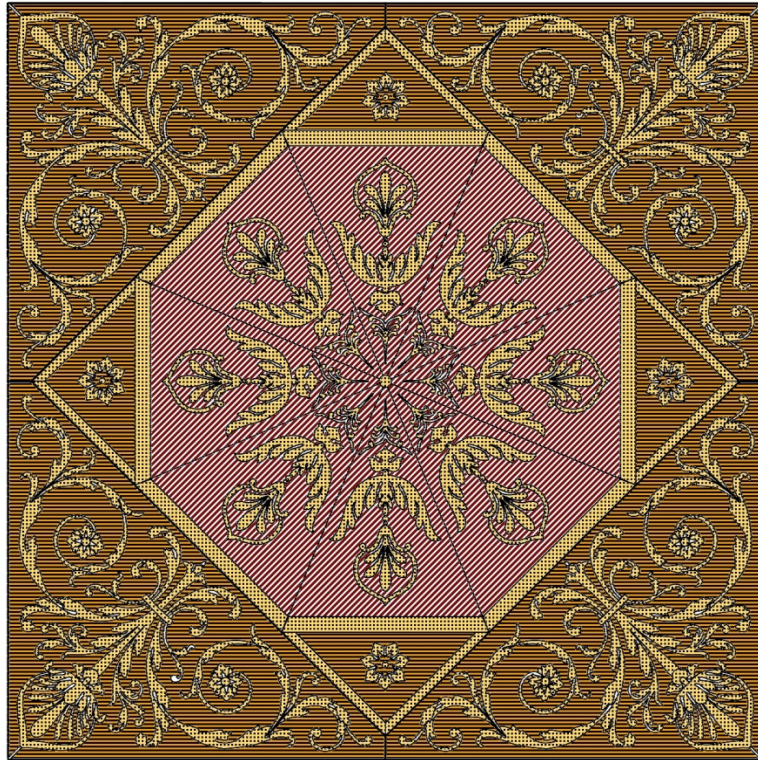
Panel elements are connected with one another with the tongue in groove joint, dowel pins and lap joint; and the connections between panels use the spline joint



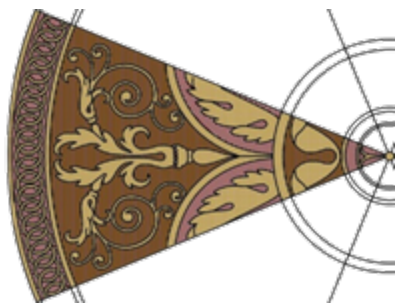
4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.1 Factors influencing the state of preservation of antique floors



- oak (*Quercus sp.*)
- fossil oak (*Quercus sp.*)
- birch (*Betula L.*)
- sycomore maple (*Acer pseudoplatanus L.*)
- hornbeam (*Carpinus L.*)
- yew (*Taxus baccata L.*)
- ash (*Fraxinus excelsior L.*)
- elm (*Ulmus L.*)
- beech (*Fagus sylvatica L.*)
- walnut (*Juglans regia L.*)
- cherry (*Cerasus Mill.*)
- mahogany (*Swietenia sp.*)
- pine (*Pinus silvestris L.*)



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.1 Factors influencing the state of preservation of antique floors



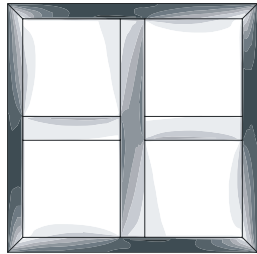
Differences in the level of antique parquets in the Łańcut Castle, resulting from a different resistance to abrasion of oak, ash and fossil oak.

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

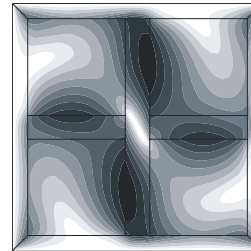
4.2.1 Factors influencing the state of preservation of antique floors

- The influence of panel design on the stability of panel dimensions



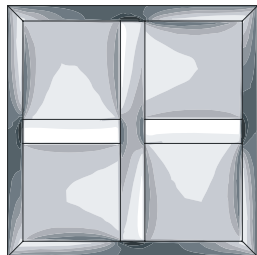
White (MIN): 16 MPa
Black (MAX): 27 MPa

White (MIN): 0,00mm
Black (MAX): 0,13mm



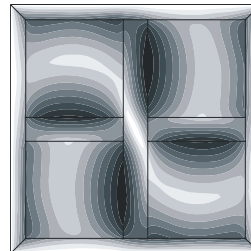
Panel of the Tarnowiec manor house, room 5 (765x765mm)

oak (*Quercus sp.*)

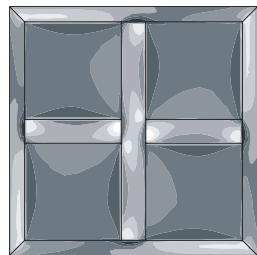


White (MIN): 17 MPa
Black (MAX): 30 MPa

White (MIN): 0,00mm
Black (MAX): 0,24mm

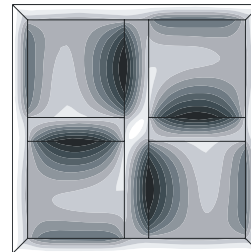


oak + pine (*Quercus sp.*, *Pinus sp.*)

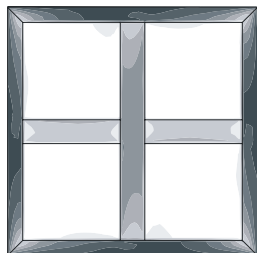


White (MIN): 18 MPa
Black (MAX): 46 MPa

White (MIN): 0,00mm
Black (MAX): 1,08mm

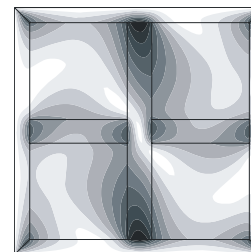


oak + beech (*Quercus sp.*, *Fagus sp.*)



White (MIN): 16 MPa
Black (MAX): 27 MPa

White (MIN): 0,00mm
Black (MAX): 0,10mm



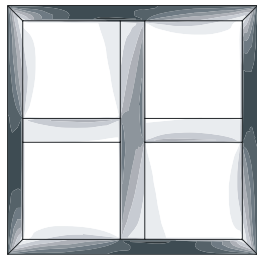
oak + elm (*Quercus sp.*, *Ulmus sp.*)

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

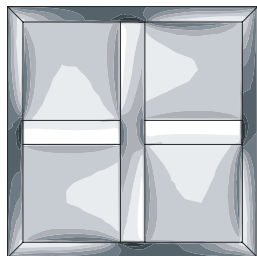
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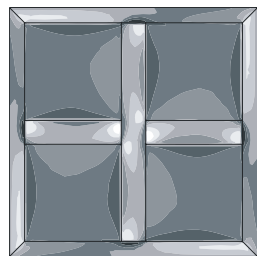
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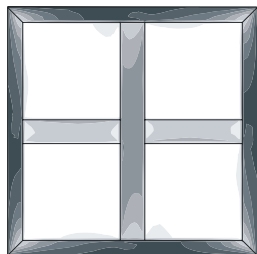
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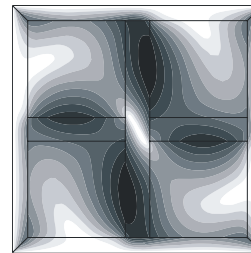
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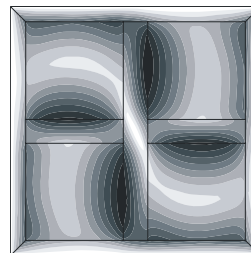
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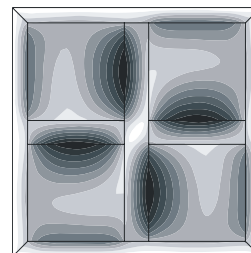


Panel of the Tarnowiec manor house, room 5 (765x765mm)

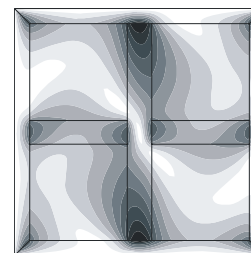
oak (*Quercus sp.*)



oak + pine (*Quercus sp.*, *Pinus sp.*)



oak + beech (*Quercus sp.*, *Fagus sp.*)



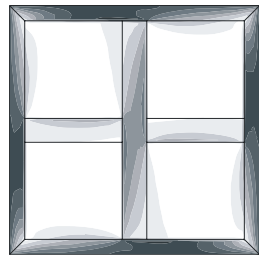
oak + elm (*Quercus sp.*, *Ulmus sp.*)

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

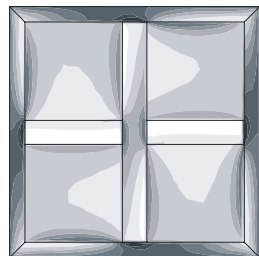
4.2.1 Factors influencing the state of preservation of antique floors

- The influence of panel design on the stability of panel dimensions



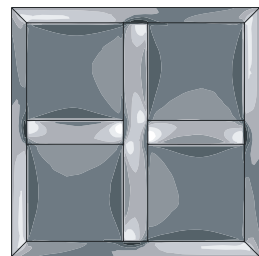
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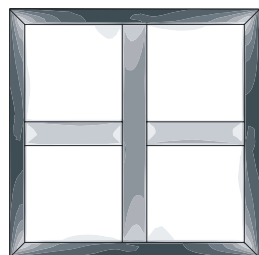
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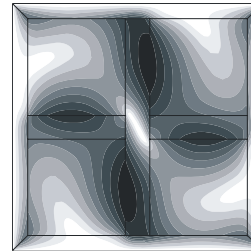
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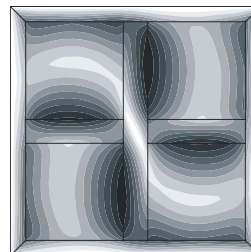


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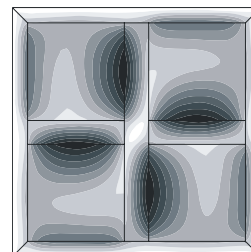
White (MIN): 0,00mm Black
(MAX): 0,10mm



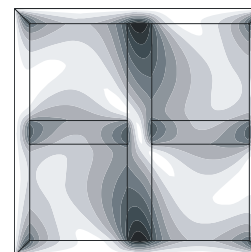
oak (*Quercus sp.*)



oak + pine (*Quercus sp.*, *Pinus sp.*)



oak + beech (*Quercus sp.*, *Fagus sp.*)



oak + elm (*Quercus sp.*, *Ulmus sp.*)

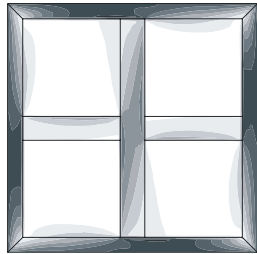
Panel of the Tarnowiec manor house, room 5 (765x765mm)

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

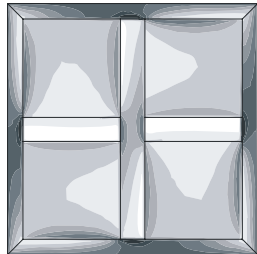
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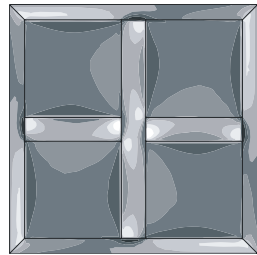
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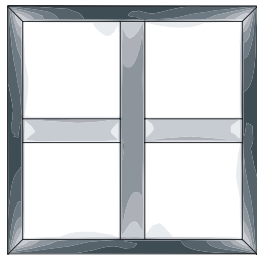
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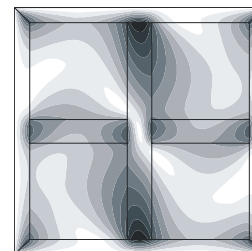
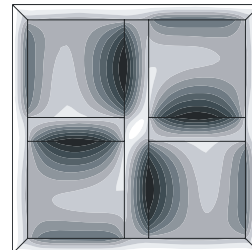
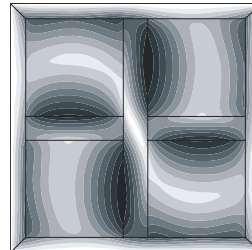
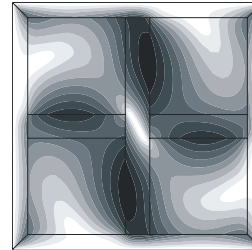
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White (MIN): 16 MPa
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White (MIN): 0,00mm Black
(MAX): 0,10mm



Panel of the Tarnowiec manor house, room 5 (765x765mm)

← wood species applied

← panel complexity

← number and proportions of elements

← minor modifications of the design of panel

← direction of fibre layout

← panel size

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.2 Resistance parameters of antique woods

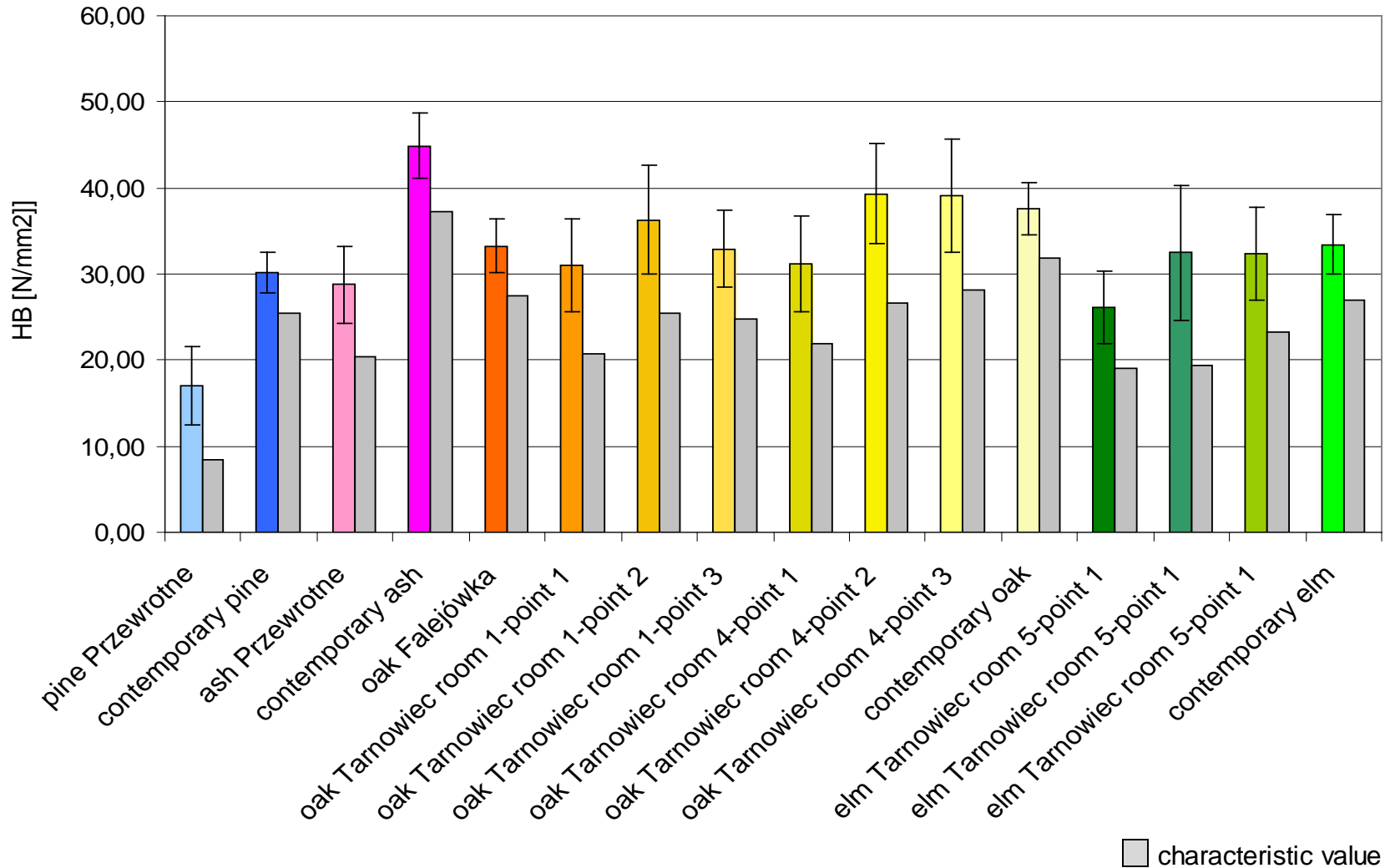
- Results of strength tests of oak wood

Manor House	Statistical value	Breaking force [N]	Bending strength [Mpa]	Modulus of elasticity [MPa]	Deflection at maximum force [mm]	Density [kg/m ³]
Falejówka	Average value	1448.35	77.55	11869.93	10.2	620
	Standard deviation	398.20	19.02	1601.13	2.87	33.29
	Coefficient of variation	27.49	24.50	13.49	28.00	5
Tarnowiec Room 1	Average value	1956.42	94.48	13029.73	11.87	720
	Standard deviation	434.99	18.87	1337.52	2.72	49.89
	Coefficient of variation	22.23	19.98	10.27	22.91	7
Tarnowiec Room 4	Average value	2024.69	76.00	11322.39	14.77	650
	Standard deviation	714.33	28.86	3029.09	2.19	37.42
	Coefficient of variation	35.28	37.97	37.97	26.73	6

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

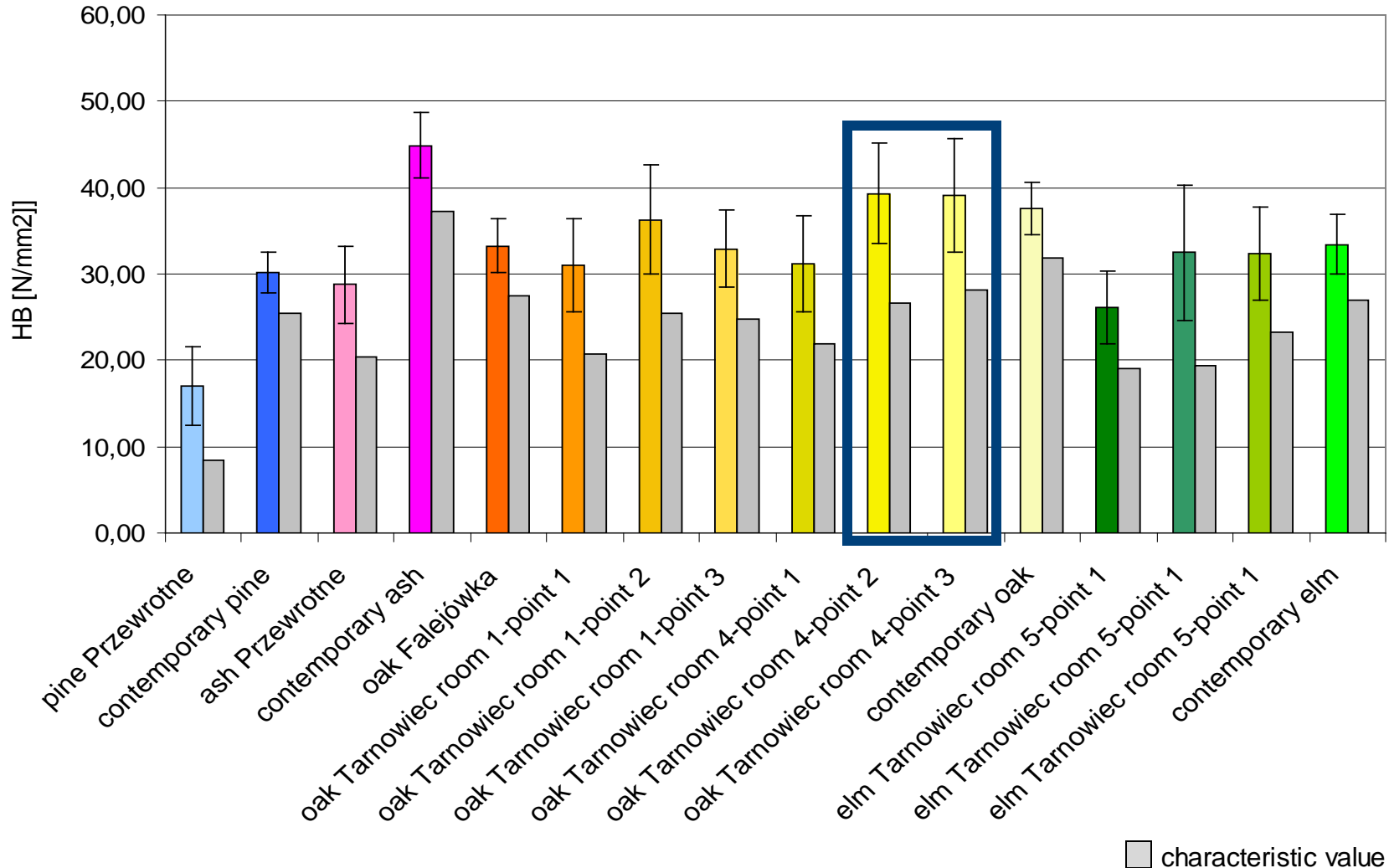
4.2.2 Resistance parameters of antique woods



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

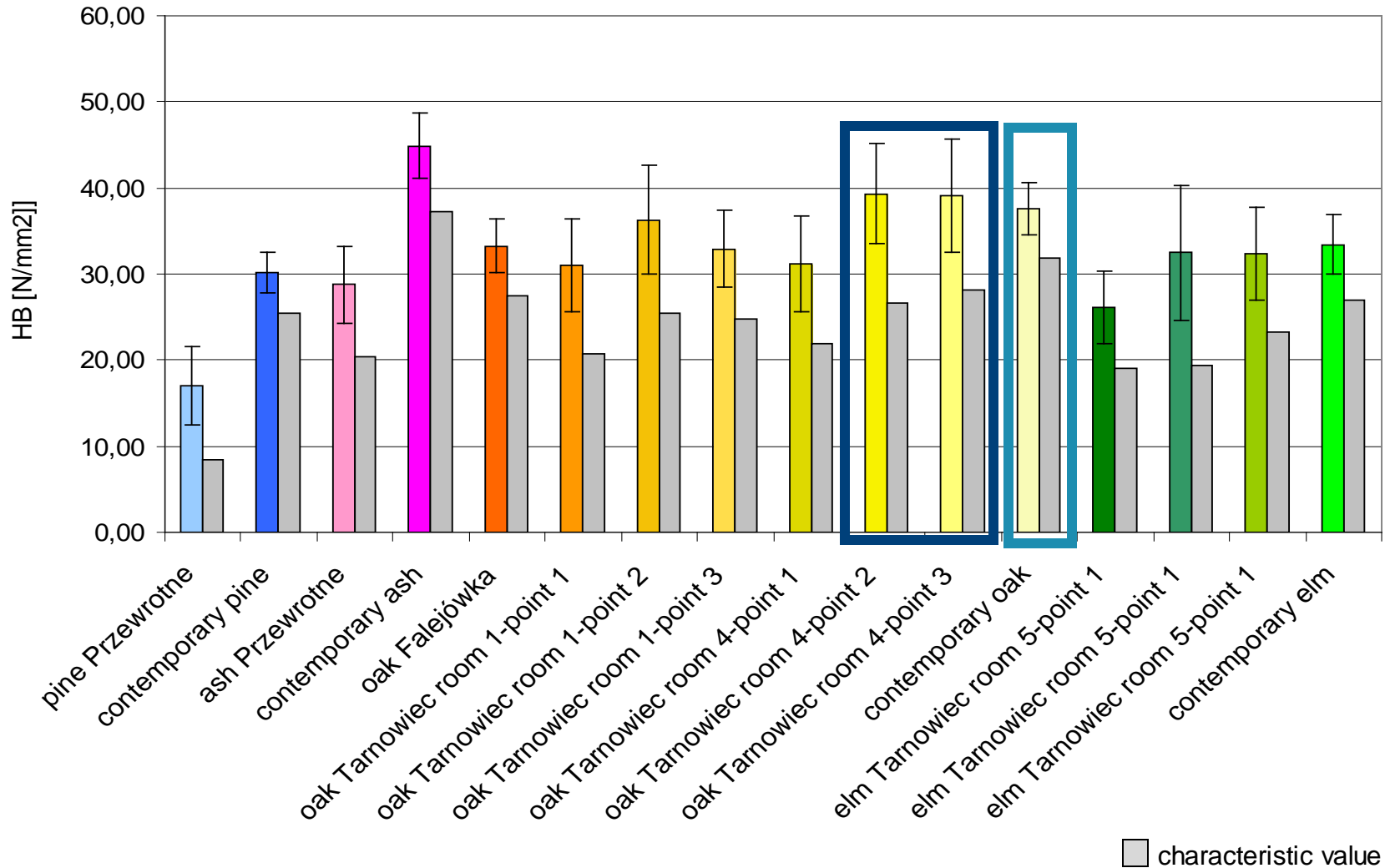
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4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

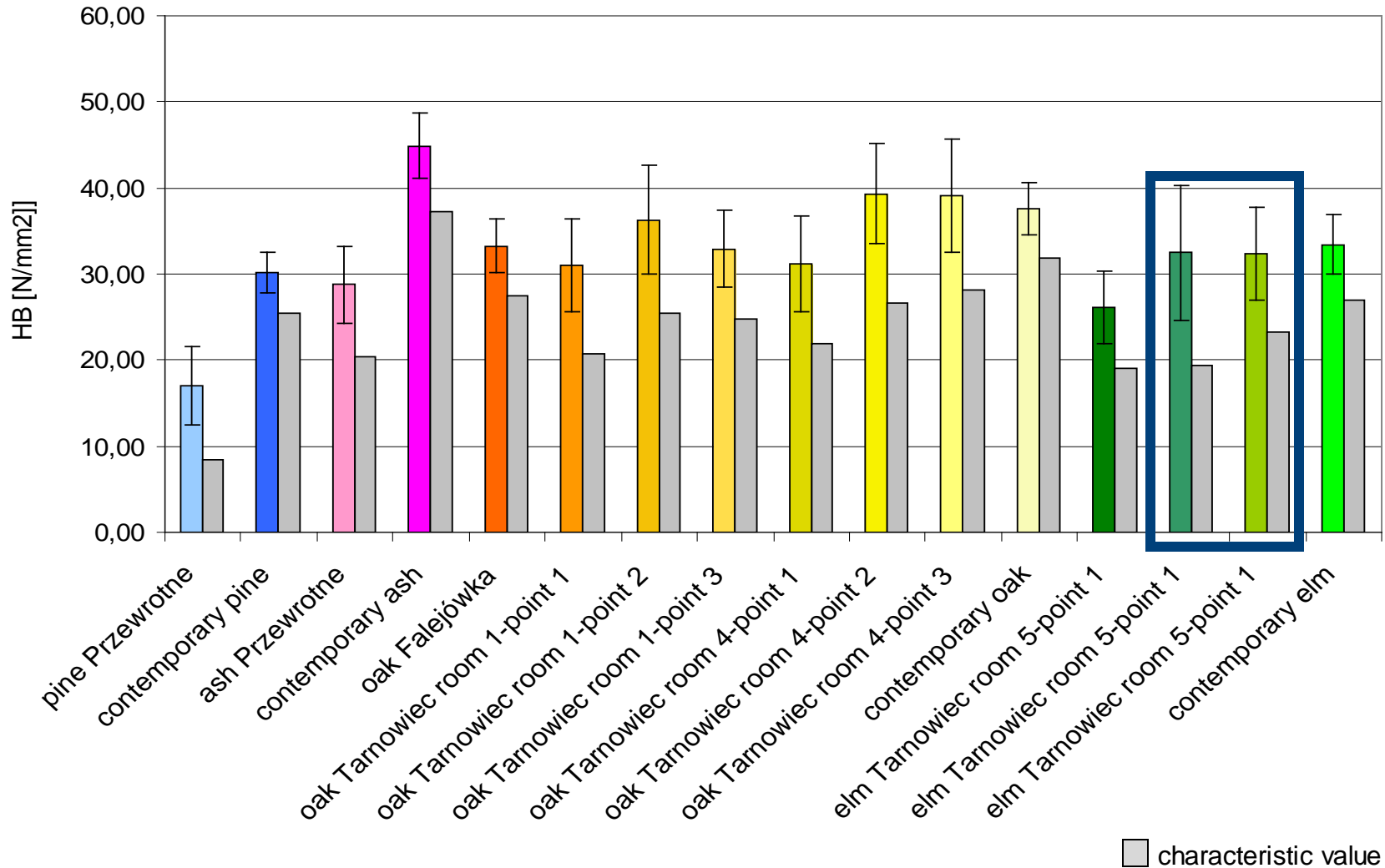
4.2.2 Resistance parameters of antique woods



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

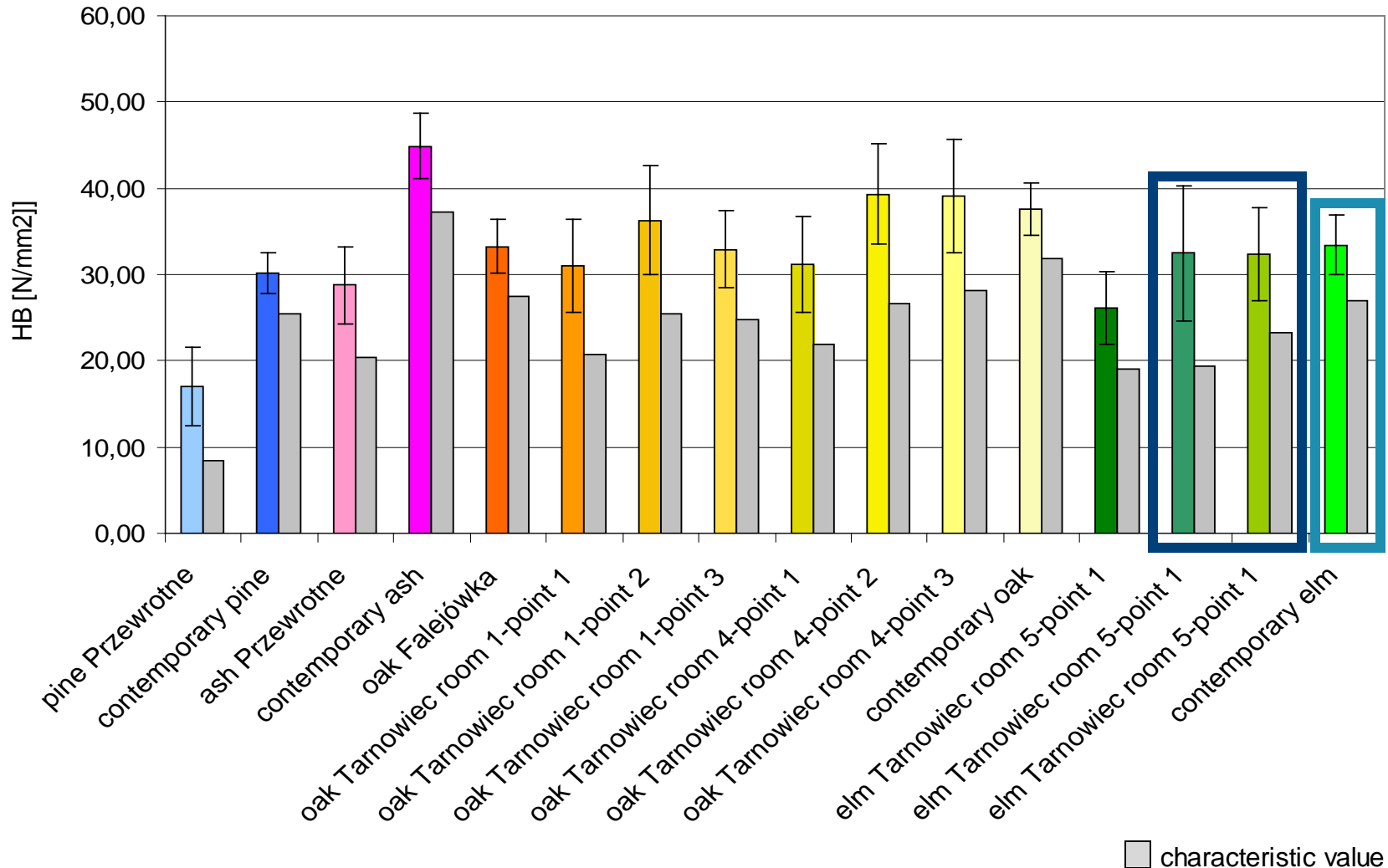
4.2.2 Resistance parameters of antique woods



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.2 Resistance parameters of antique woods



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.3 Static and dynamic load bearing capacity of antique floors

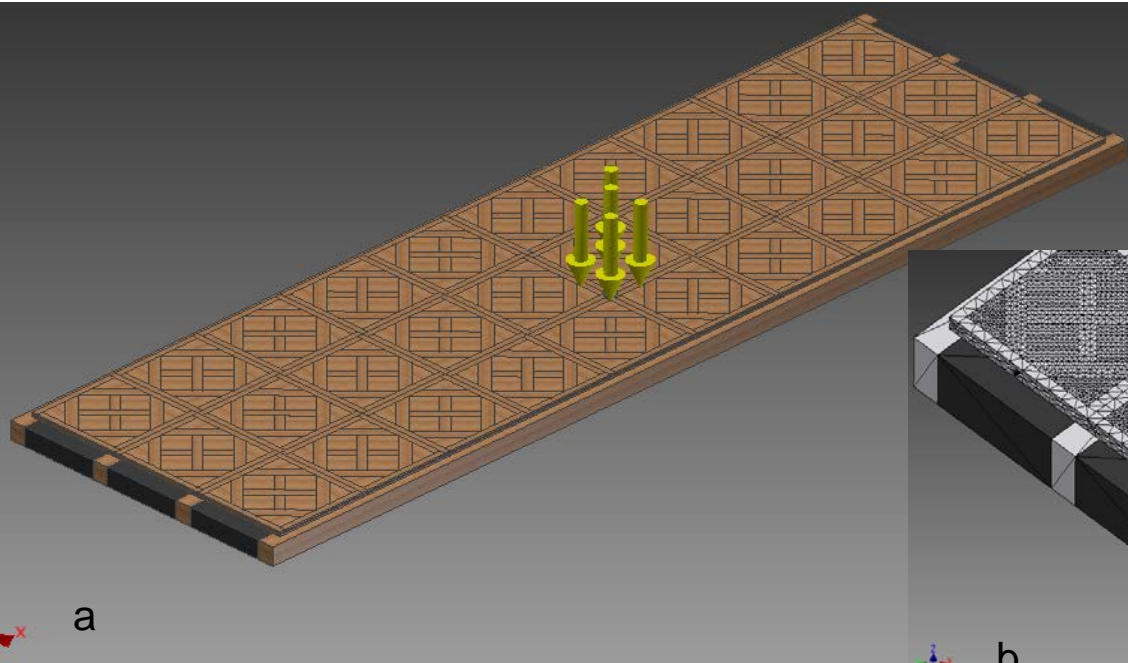
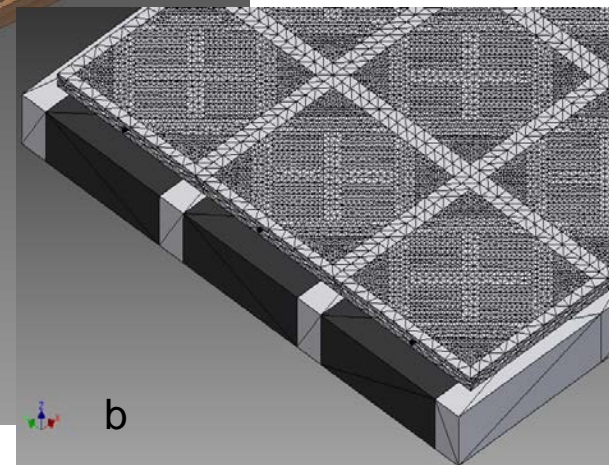


Diagram of dead and live (imposed) structural loads (0.1 MPa) of parquet from Room no. 4 in Tarnowiec (a) together with the grid (b) using the finite element method.



The load was applied in two most critical points of the parquet: in the middle of the panel: F2; and at the limit between two adjacent panels: F1 in two parquet variants: contemporary and antique.

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.3 Static and dynamic load bearing capacity of antique floors

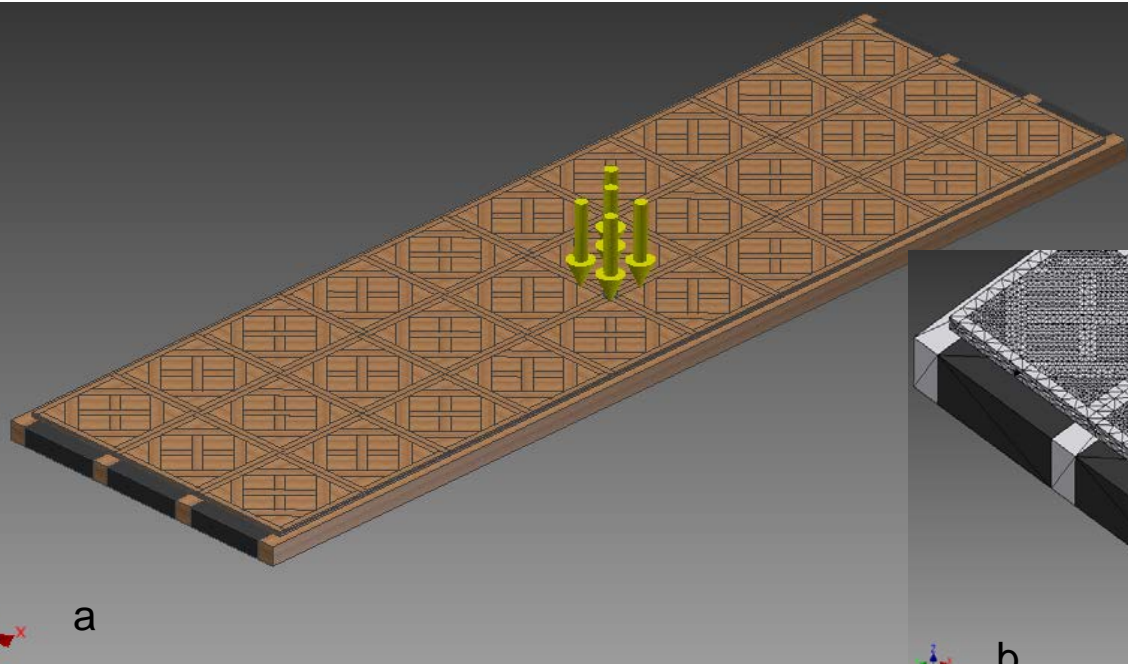
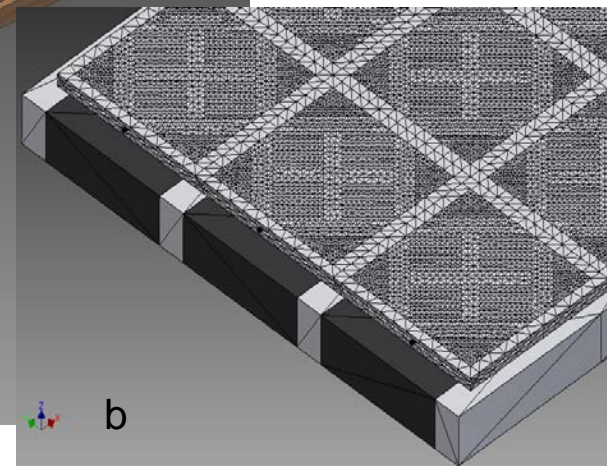


Diagram of dead and live (imposed) structural loads (0.1 MPa) of parquet from Room no. 4 in Tarnowiec (a) together with the grid (b) using the finite element method.



The load was applied in two most critical points of the parquet: in the middle of the panel: F2; and at the limit between two adjacent panels: F1 in two parquet variants: contemporary and antique.

Simulation results	Floor structure of Tarnowiec Room 1				Floor structure of Tarnowiec Room 4			
	Contemporary wood		Antique wood		Contemporary wood		Antique wood	
	F1	F2	F1	F2	F1	F2	F1	F2
Maximum von Mises stress [MPa]	0.17	0.49	0.18	0.43	0.20	0.44	0.20	0.44
Maximum deflection [mm]	0.0013	0.023	0.0015	0.023	0.0006	0.0098	0.0015	0.011

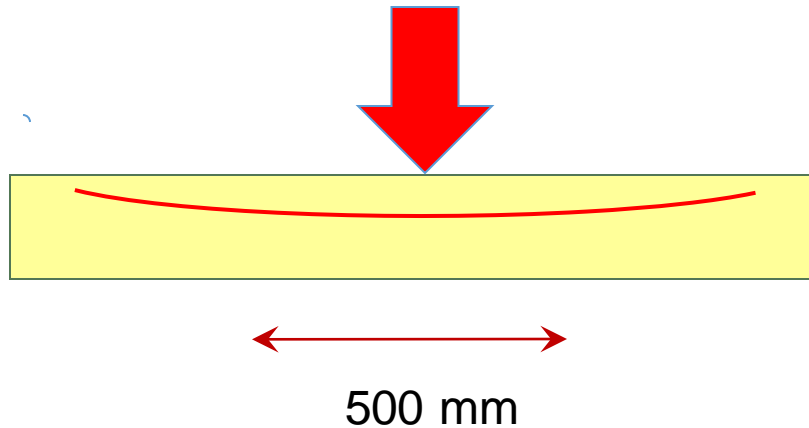
4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.3 Static and dynamic load bearing capacity of antique floors

Panel parquets are similar to area elastic sports floors

PN-EN 14904:2000



parquet

top transversal joists

bottom longitudinal joists

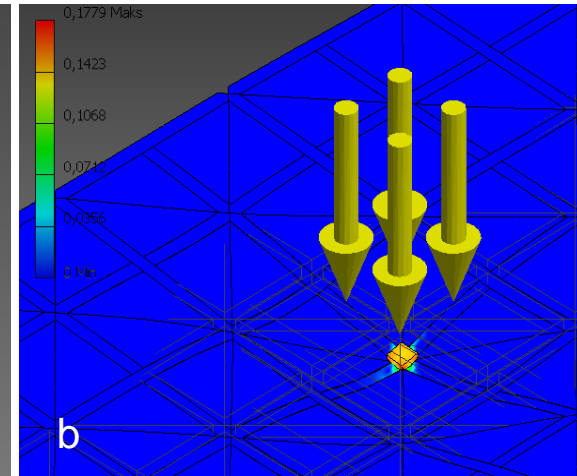
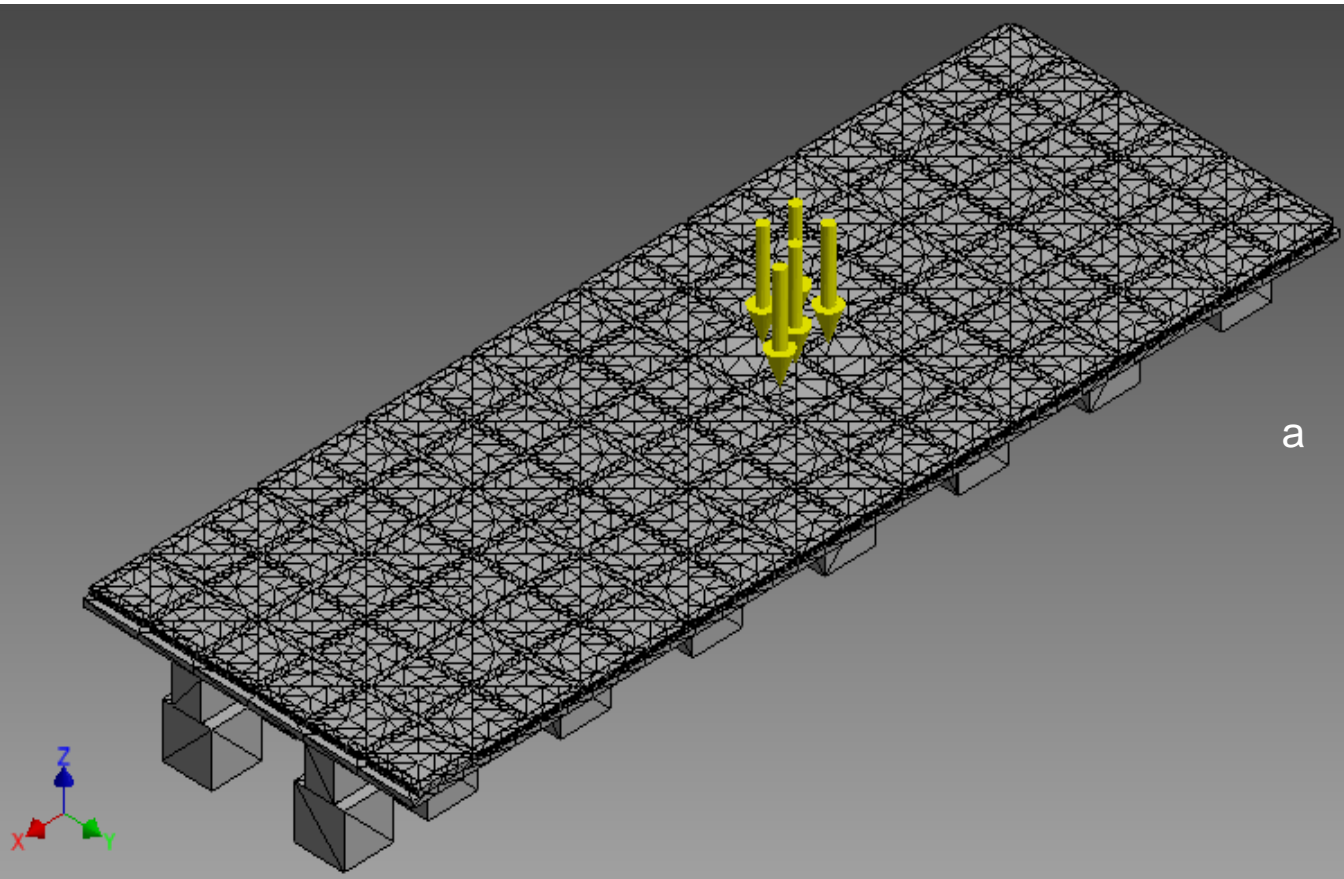
elastic pads

concrete base

4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.3 Static and dynamic load bearing capacity of antique floors

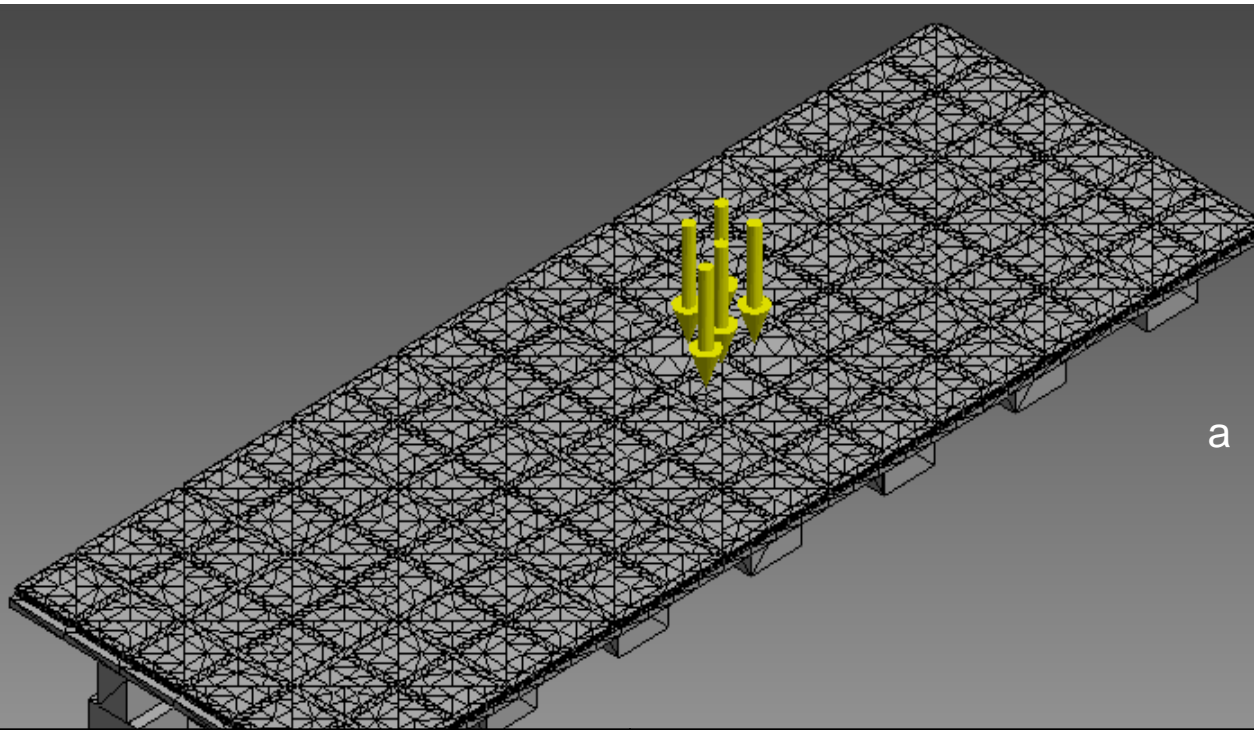


The function of joints in the structure of antique wooden tile parquets on the example of parquet from Przewrotne manor house - diagram of dead and live (imposed) structural loads (0.15 MPa) together with the grid (a) and the deformations (b) with the use of the finite element method

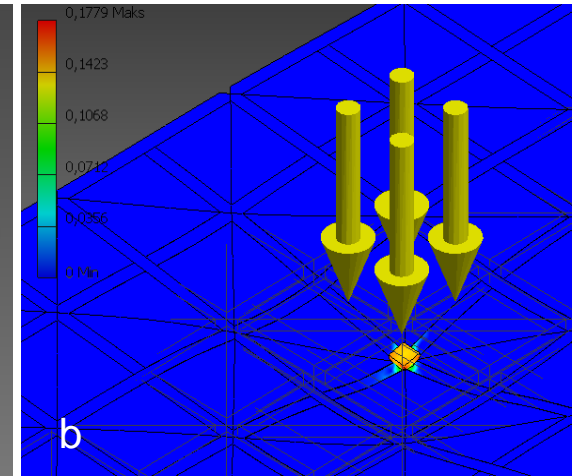
4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.3 Static and dynamic load bearing capacity of antique floors



a



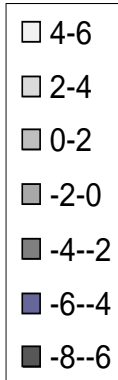
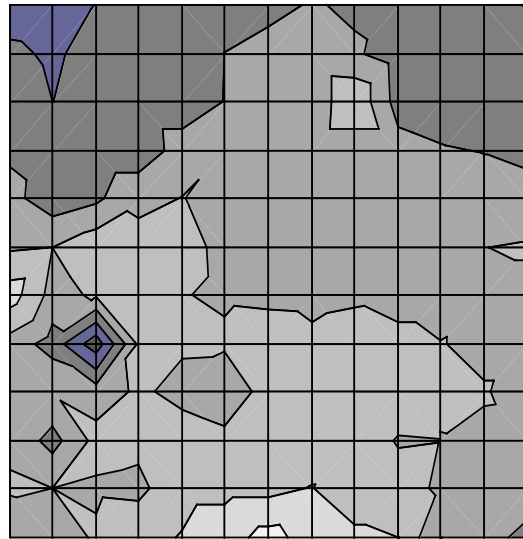
The function of joints in the structure of antique wooden tile parquets on the example of parquet from Przewrotne manor house - diagram of dead and live (imposed)

Simulation results		Maximum von Mises stress [MPa]	Maximum deflection [mm]
Panel with profiled joints	F1	0.166	0.0008
	F2	0.179	0.0034
Panel without profiled joints	F1	0.168	0.0005
	F2	0.178	0.0032

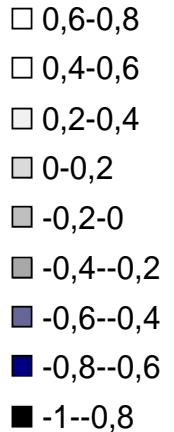
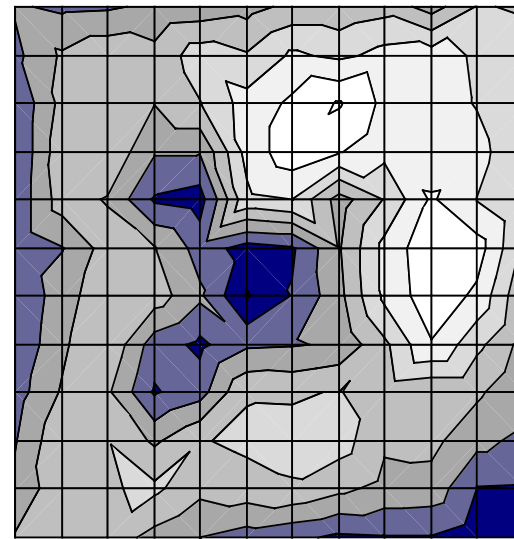
4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.4 Flatness and shape deformations



a



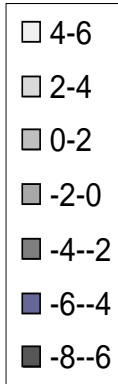
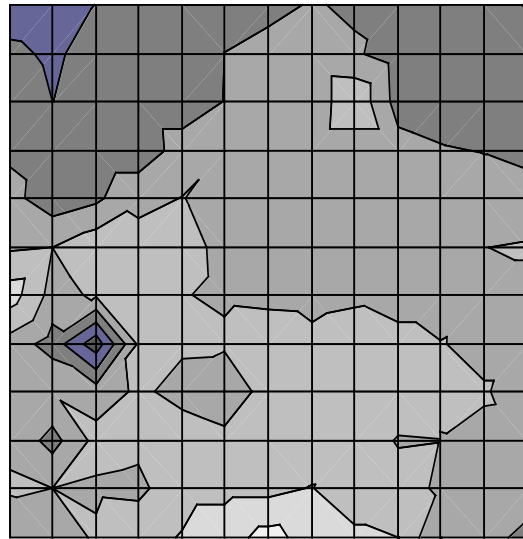
b

Deviations from flatness of an antique panel from Room no. 4 in Tarnowiec Manor House (a) and its contemporary copy (b). The curvature was measured on the front side of the panels in points marked by the virtual mesh, size 50 x 50 mm. As a result of the measurements, we obtained an “altitude map” that shows the degree of deviation from flatness in relation with the surface of the entire panel.

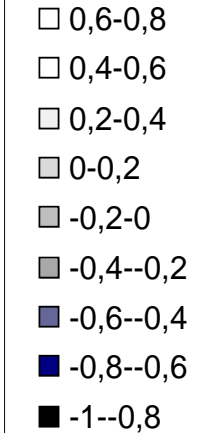
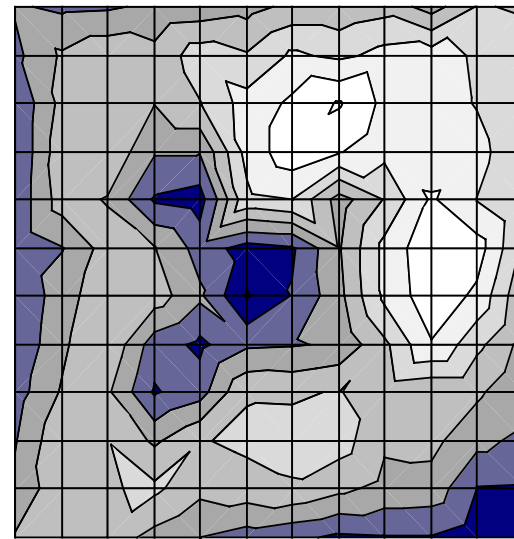
4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

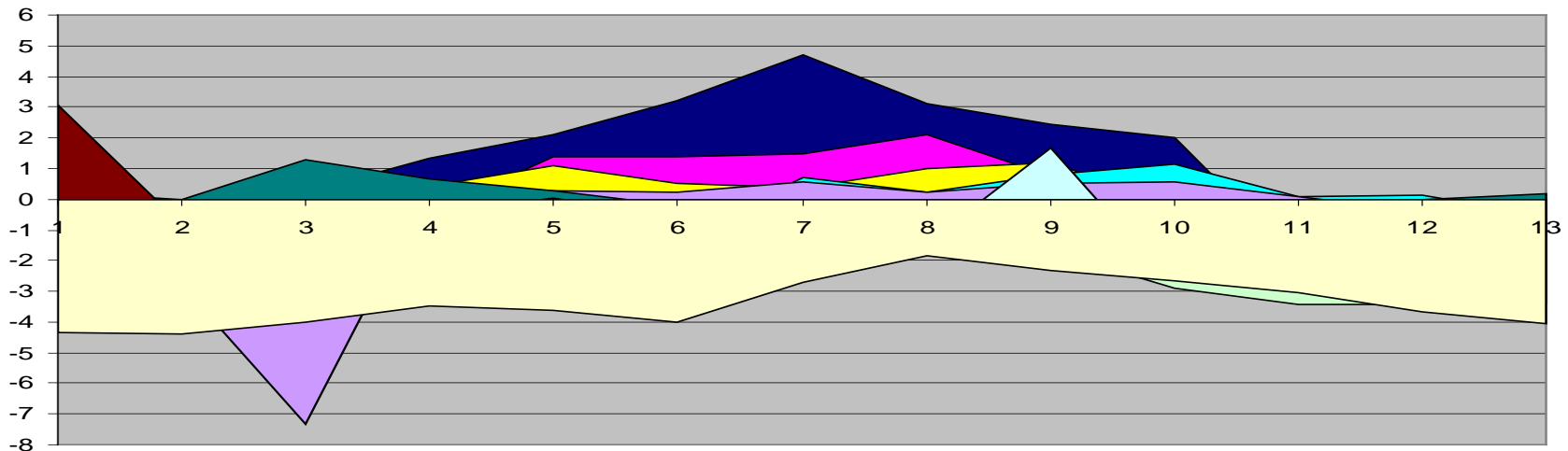
4.2.4 Flatness and shape deformations



a



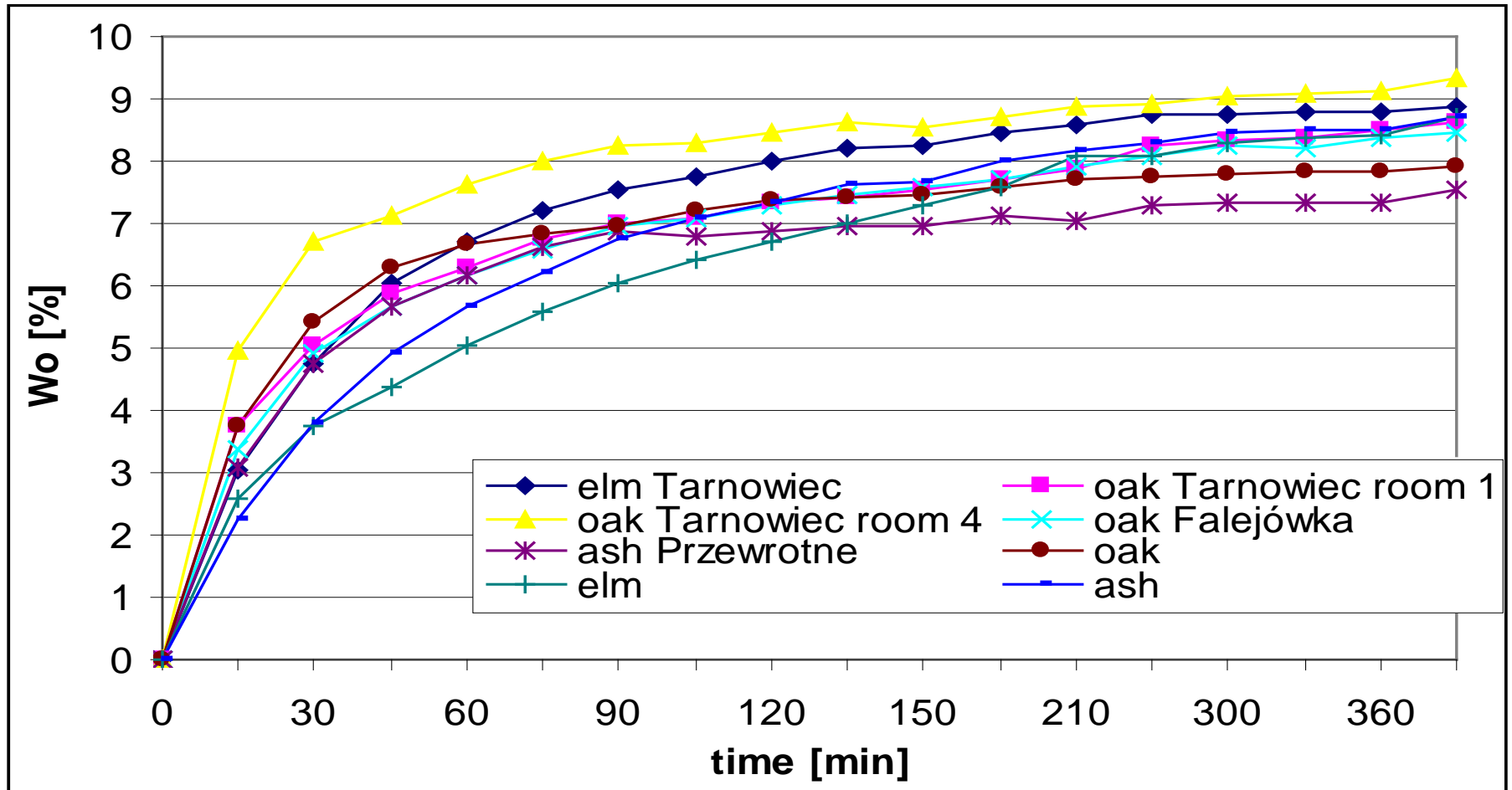
b



4. TEST RESULTS

4.2 Selected Results of Antique Floor Usage Tests

4.2.5 Chemical composition and fungi infestation

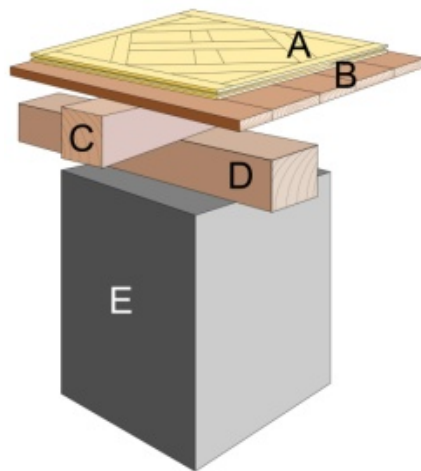
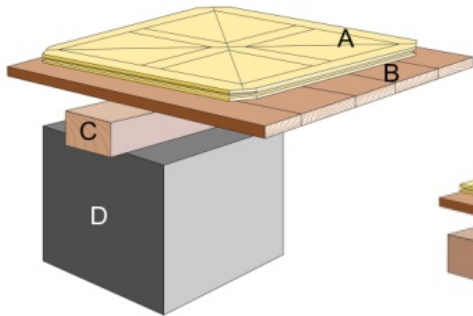
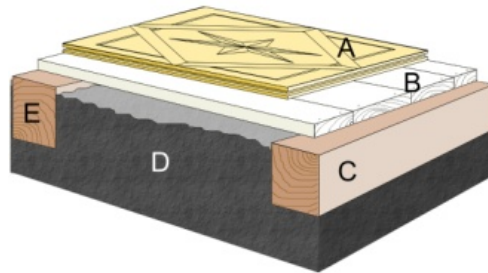


Wettability curves of the heartwood of antique wood and of contemporary oak, ash and elm

4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

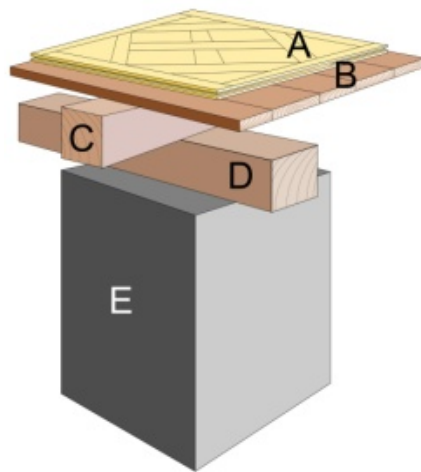
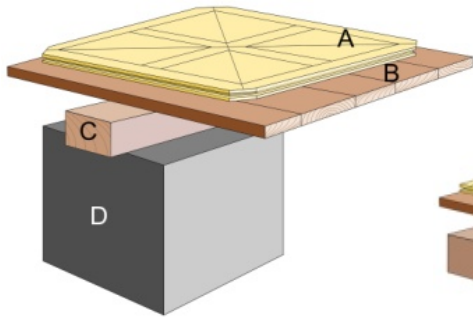
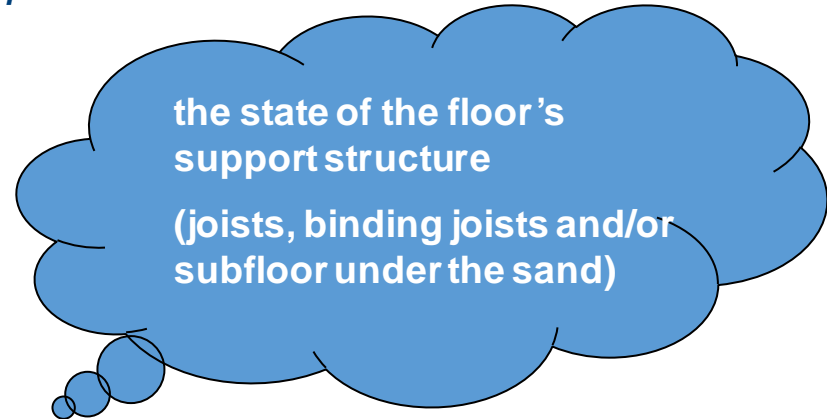
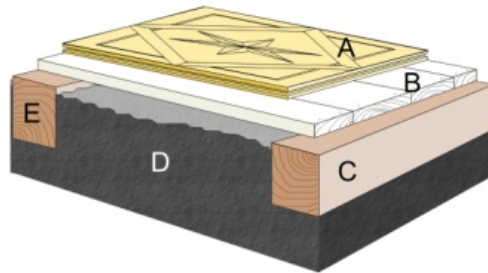
4.3.1 Design and material requirements



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

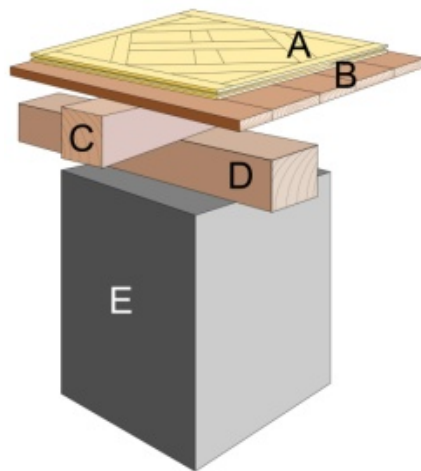
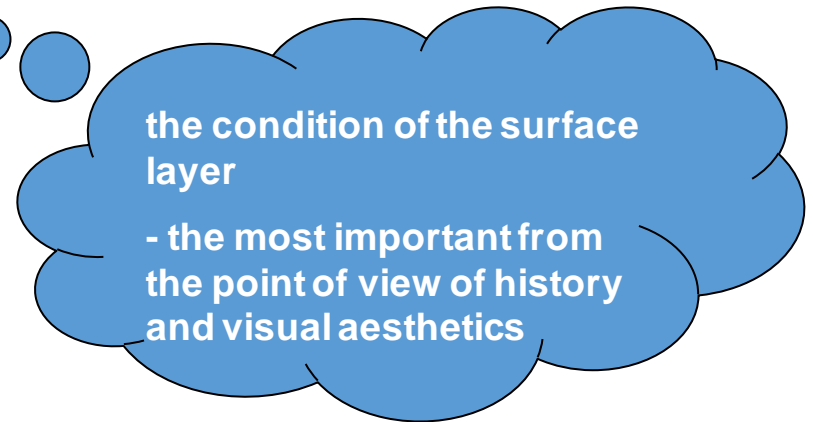
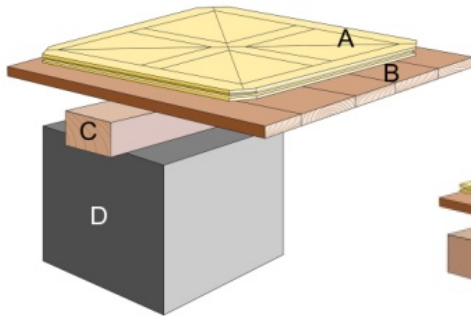
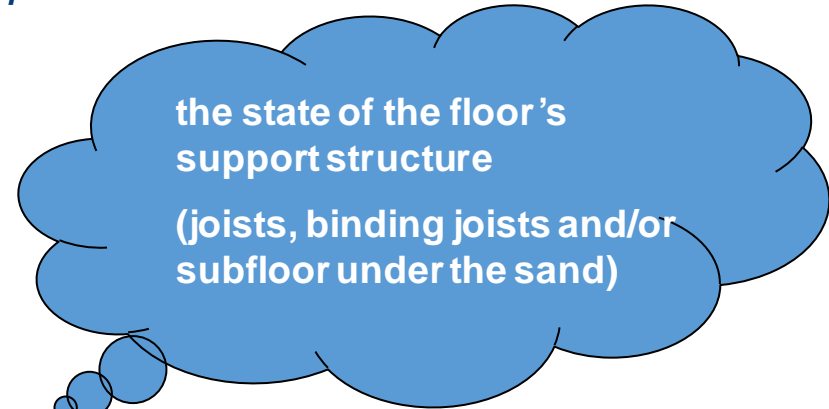
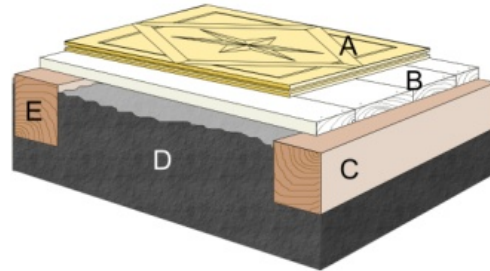
4.3.1 Design and material requirements



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

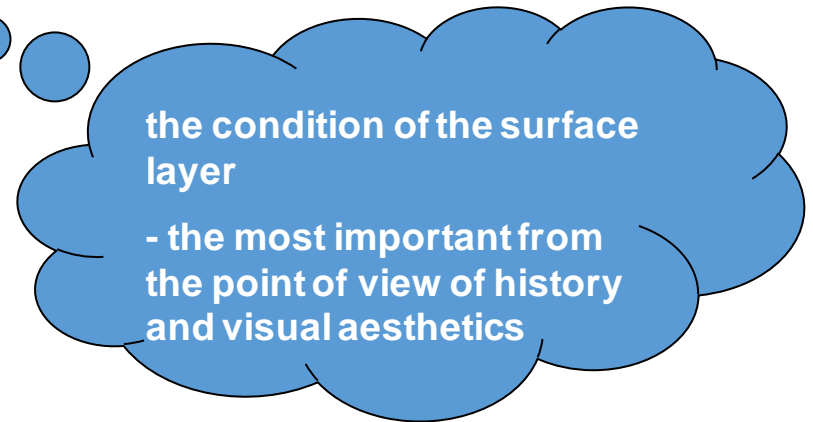
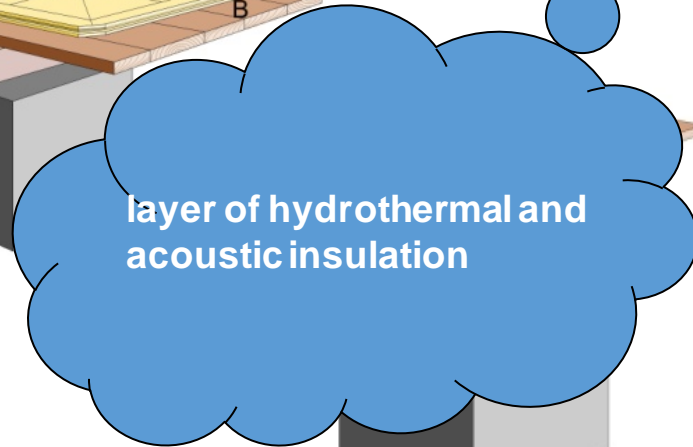
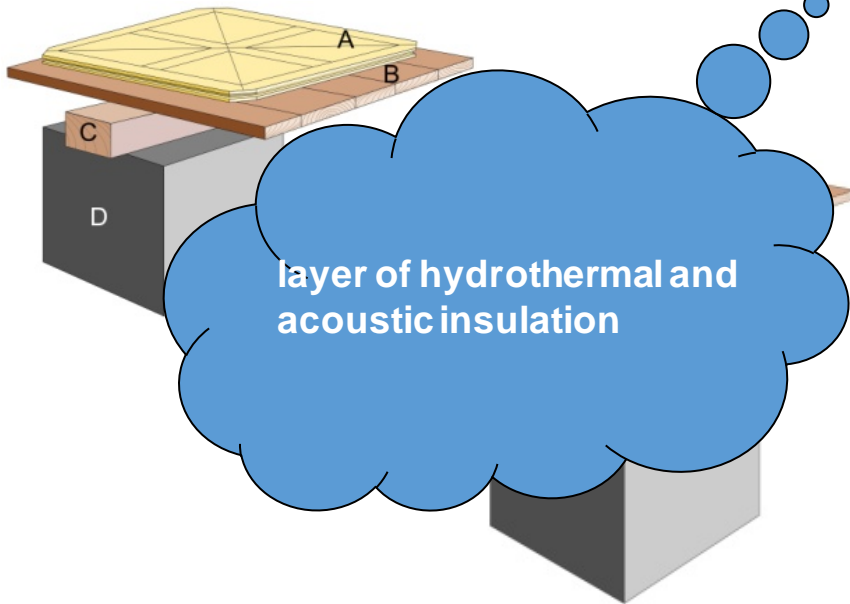
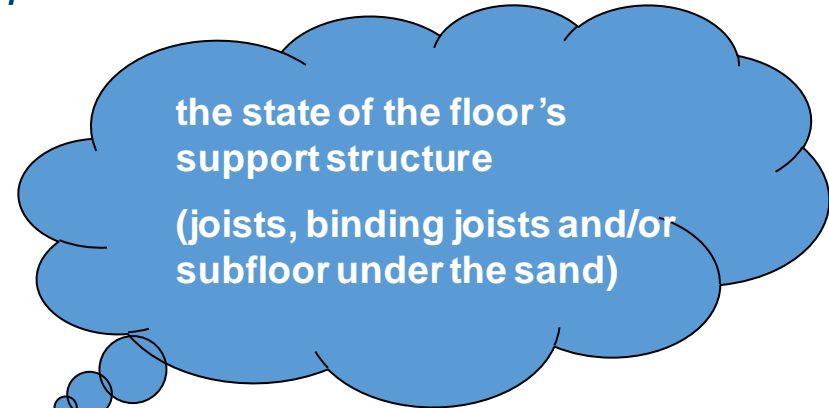
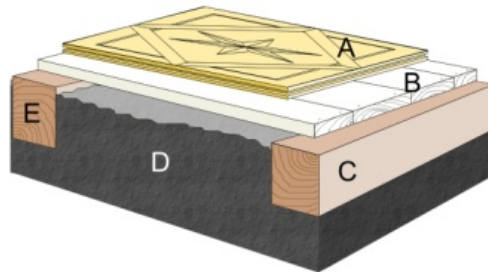
4.3.1 Design and material requirements



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

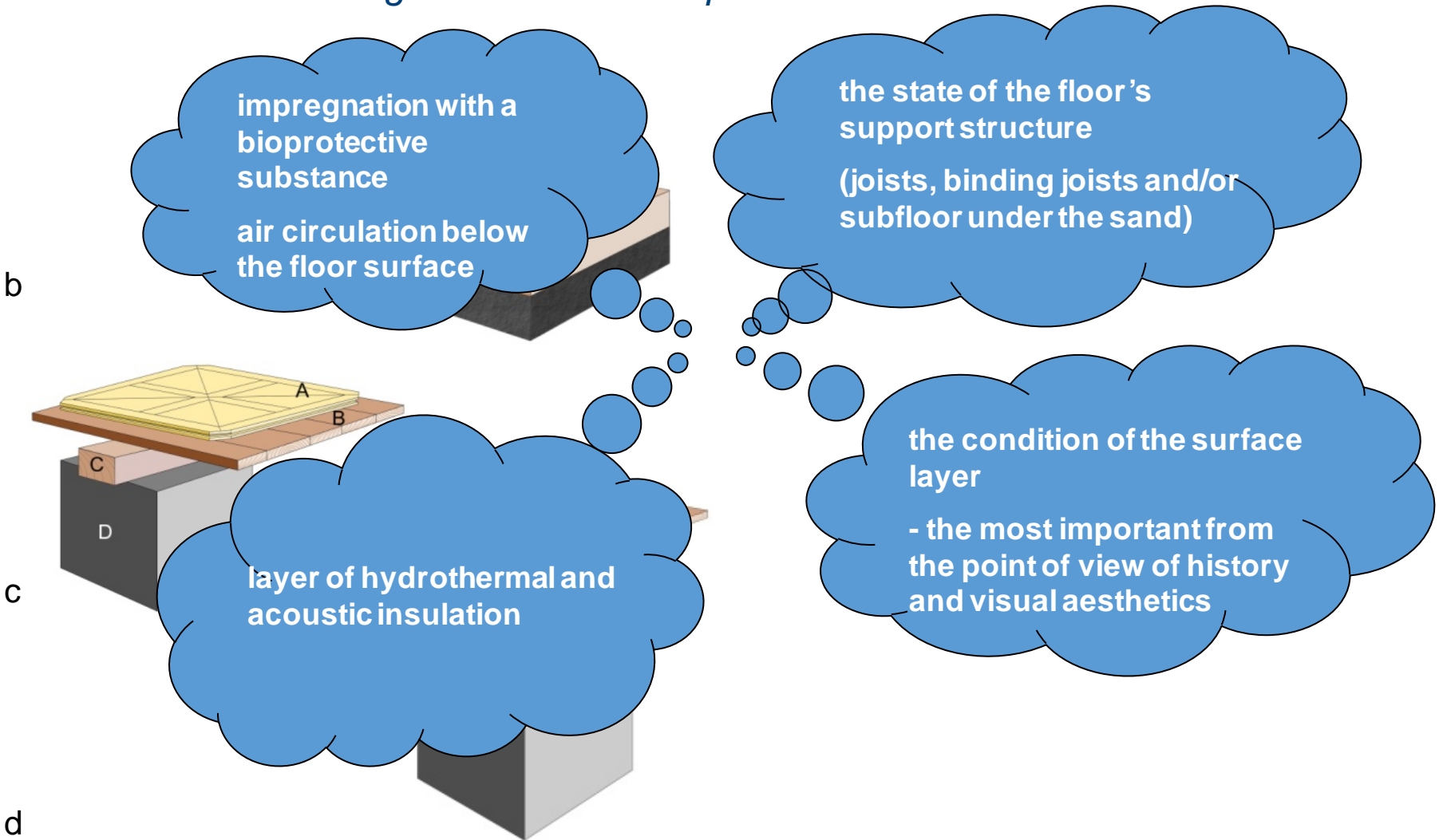
4.3.1 Design and material requirements



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

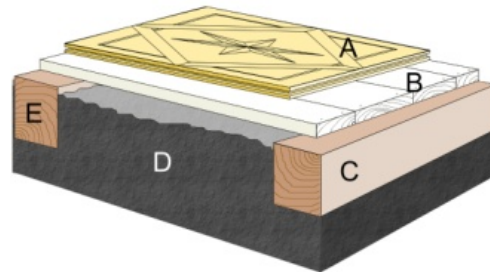
4.3.1 Design and material requirements



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

4.3.1 Design and material requirements



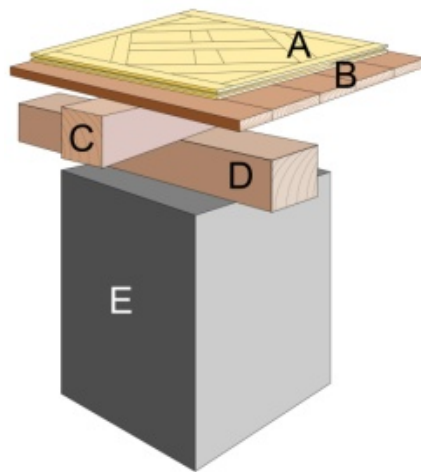
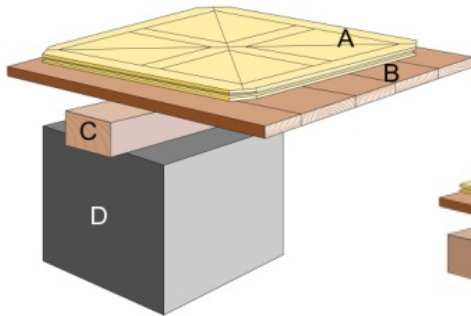
The dimensions of the cross-section of load bearing elements that transfer loads from the floor, such as joists, binding joists or bricked posts, have to be designed in accordance with the requirements of the designing standards specified in Eurocode EC 5.

Structural elements can be made only of wood approved for construction applications, that is coniferous wood (spruce, pine, fir or larch) that has been strength graded and has a defined strength class C.

The wood has to be marked with a CE mark and should fulfil the requirements of the EN 14081 standard.

The blind floors should be made of strength sorted pine wood planks with joists (dowel type fasteners that fulfill the requirements of the EN 14592 standard) or of engineered wood panels, under the condition that they meet the requirements of EN 13986.

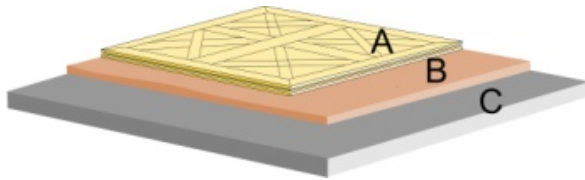
The thickness of planks as well as the amount and type of joints have to be specified on the basis of resistance calculations in line with EN 1995-1-1 or tests carried out in accordance with EN 1195 and EN 12871.



4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

4.3.1 Design and material requirements



The loads can also be transferred through another structural element - a solid base, usually (in case of contemporary floors) made of concrete or screed.

The mineral subfloors are made of crushed stone and a binding agent (cement/anhydrite), in the proportion that is in line with the recipe indicated for a given compressive strength, or a ready mix whose properties are declared by the manufacturer, in accordance with the EN 13813 and EN 13318 standards.

Floor elements made of solid wood and of multiple layers of broadleaf or coniferous wood, in accordance with EN 14342 and with one of the product standards mentioned below: EN13226, EN13227; EN13228; EN13488; EN13489, EN 13629, EN 13990; EN 14761 shall be used to manufacture parquets glued to a mineral base or glued (and/or also nailed) to a subfloor made of planks (the so called blind floor).

Fasteners - nails, staples, screws should meet the requirements of the EN 14592.

4. TEST RESULTS

4.3 Usage Requirements for Antique Wooden Floors and the Programme of Conservation Works

4.3.2 Usage conditions of wooden panel parquets

Proper insulation against humidity, always between the brick base and the wooden element.

All the “wet” works in the building must already be finished, internal woodwork installed, and heating must be turned on. In accordance with the recommendations from reference literature, the panels should be kept in microclimate conditions typical for interiors for several weeks in advance, and the works should be carried out in about 20° C and relative air humidity 50-65%.

Instead of the layer of sand or wooden wedges that were used under the panels for levelling in antique parquets, decking can be covered with a vapour insulating foil with foam that is used under floating floors.

In conservation works, it is recommended to use traditional wood surface finishes - oil or wax.

5. CONCLUSIONS - antique floors

- The fact that elements of wooden parquets have been preserved for almost 200 years shows that the **wood quality was high**; at the same time, the **technical condition of the assessed floors was diverse** and resulted from individual factors, most of all usage intensity and assembly technique.
- The decision on whether to renovate or replace antique parquet should be made **on the basis of resistance tests carried out on the antique parquet**, which allows for a correct assessment of the possibility of its further usage.
- The following wood properties are considered important: **density, bending strength, hardness, resistance to abrasion, resistance to scratches**, the level of **fungi infestation** assessed visually and with the help of **ergosterol determination, wettability curves, moisture equivalent**, as well as the quantitative and qualitative **chemical composition**.
- The test results of antique floor usage properties can provide a basis for **numerical simulations** specifying the capability of antique floors to transfer static and dynamic loads.
- **Fungi infestation** of antique wooden floors **does not always entail the need of replacement**.
- In case of antique parquet conservation, **we are not able to achieve the “perfectly flat” surface** that is preferred in contemporary parquets.

5. CONCLUSIONS – reconstructed floors

- Parquets based on conservators' patterns and assembled with traditional methods should **meet both the aesthetic** (the way they look and the general impression) and **technical requirements** binding nowadays, such as **flatness, slope** (where necessary), **dimensional stability, resistance to abrasion of the coating, hardness, scratches, gloss**, and in ball rooms, additionally, the **capability to absorb energy in the required force reduction range**.
- It is recommended to use **oak** wood or **ash** wood (beech is not recommended because of its moisture exchange time).
- The structural and filling elements of the reconstructed **parquet should have the same thickness**.
- Due to the fact that the **parquet must be placed on decking**, its **thickness might be smaller** than the thickness of antique parquets supported only by joists, and adjusted to the universally available wood assortment.
- For aesthetic and structural reasons, the reconstructed panels should **include profiled woodwork joints**.
- **The conservation work should be recommended to contemporary standards - for materials, designs and workmanship, wherever this is possible, with respect for the past and tradition.**

A close-up photograph of a highly decorative wooden floor. The floor features a complex, symmetrical pattern of interlocking floral and leaf motifs, known as Lancut Castle parquet. The design is rendered in a light, golden-brown hue against a darker, reddish-brown wood background. The pattern is divided into sections by thin, dark lines, and the overall appearance is that of a traditional, hand-crafted wooden floor.

*Łancut Castle parquet

Thank you for your attention!

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Manor House	Date back	Basement	Floor structure	Wood species	Sampling point
Tarnowiec Room no. 1	ca.1930	+	sand+ joists+ boarding	Oak <i>Quercus</i> sp.	External corner of the room
Tarnowiec Room no. 1	ca.1930	+	sand+ joists+ boarding		Communication
Tarnowiec Room no. 1	ca.1930	+	sand+ joists+ boarding		Internal corner of the room
Tarnowiec Room no. 4	ca.1930	-	sand+ joists	Oak <i>Quercus</i> sp.	External corner of the room
Tarnowiec Room no. 4	ca.1930	-	sand+ joists		Communication
Tarnowiec Room no. 4	ca.1930	-	sand+ joists		Internal corner of the room
Tarnowiec Room no. 5	ca.1930	-	sand+ joists	Elm <i>Ulmus minor</i> Mill.	External corner of the room
Tarnowiec Room no. 5	ca.1930	-	sand+ joists		Communication
Tarnowiec Room no. 5	ca.1930	-	sand+ joists		Internal corner of the room
Falejówka	2 nd half 19 th c.	-	empty sp.+ beams+ boarding	<i>Quercus</i> sp.	Whole room
pine	contemp.	-	-	<i>Pinus sylvestris</i> L.	-
ash	contemp.	-	-	<i>Fraxinus excelsior</i> L.	-
oak	contemp..	-	-	Oak <i>Quercus robur</i> L.	-
elm	contemp.	-	-	Elm <i>Ulmus minor</i> Mill.	-