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WOODEN FLOORING – BETWEEN PRESENT AND FUTURE

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Abstract:
The paper aims at presenting a systematization of the wood floors, both in terms of the areas of application, and in terms of the fastening solutions and structures in constructions. In this respect, an extensive bibliographic research was achieved, on the researchers' preoccupations.
Starting from the current situation and forecasting the future, from the point of view of the chances held by wooden flooring, in competition with other types of materials, we dare say the wooden flooring or the wood in combination with other materials are not likely to be eliminated from the "civil-engineering market". The wood floors are likely to develop as an application, especially in the area of the "special floors", specific to the indoor sports or social halls; and even for some industrial sectors, with strict operating conditions (elasticity, thermal insulation, soundproofing) that cannot be provided by other types of materials or structures. Starting from this last observation, the paper also aims at submitting current opinions with respect to this type of floors, both in the light of the current databases and in the light of the future researches, to this end.

Key words: *wooden flooring; structures; fastening solutions; utilisation.*

INTRODUCTION

Wood is a natural, biodegradable product, with non-homogeneous and anisotropous structure, with several improvable properties (related to bio-endurance, dimensional stability, swelling-contraction, density and others), with a view to its being used in different fields (such as wood floors) and environments (industrial, commercial, socio-cultural). In this light, many specialists, on both a national and international level, conducted various researches, meant to result in improved wood qualities; necessary for its use in manufacturing floors in wood and in semi-finished wood-based materials. In this way, several thermal-treatment procedures and methods have been tested, with a view to improving the wood properties.

The thermal treatment of wood (at 180^0C...220^0C) in an oxygen-poor environment (for instance, in steam or nitrogen), (Sailer *et al*. 2000, Wang and Cooper 2005) has led to improved dimensional stability, by the drop in hygroscopicity. Other researchers (Wang and Cooper 2003, Hill 2006, Esteves and Pereira 2009), who also reported to the thermal treatment of wood, yet with hot oil, have proved that the dimensional stability is thereby improved, in terms of swelling and contraction, compared to untreated wood, also having low moisture balance. Likewise, the wood colour is thereby stabilized and its resistance is improved. Another thermal treatment of wood with thermal oil (Nejad *et al*. 2013) has been achieved, with a view to finding a water-based ecological product, for the coverage of the various wood-species surfaces (American beech and maple), used in wood floors, which should lead to its increased adherence on the treated-wood surface and to increased scratch resistance. The treatment of wood with microwaves (Dömény *et al*. 2014) in view of its plastification and densification, so that it might be used in beechwood floorings, targeted its increased plasticity and its streamlined compression process; hence it may be deemed a pre-treatment of wood (Norimoto and Gril 1989, Studhalter *et al*. 2009, Ozarska and Daian 2010, Gasparik and Gaff 2013). The strength and resistance are in direct proportion with the wood density (Kollmann and Côté 1968); the subsequent researches (Navi and Heger 2004, Kamke 2006, Fang *et al*. 2012) have confirmed their dependence on wood density, by resorting to veneer compressed under the influence of steam, pressure and temperature. Others (Lamason and Gong 2007) have dealt with the optimization of the processing parameters for the mechanically densified surfaces, in poplar wood. Another variant of thermal treatment of wood (at 180 and 200^{0}C) has been achieved by means of repeated soaks (Čermák *et al*. 2015), for the species of poplar, beech and spruce, noticing significant chemical changes, by the diminished hemicellulose percentage and by the increased quantity of extractive substances.

In our country, the theme of the thermal treatment of wood, with a view to its being used in wood floors has been approached (Comșa and Comșa 2006), for the purposes of improved colour stabilization, so as to achieve floors with high aesthetics.

In addition to the researches upon dimensional stability, colouristic, improved resistance by densification, other studies have been conducted on the behaviour under fire, of the floors in both wood and other materials, (Kim *et al*. 2011) with the *cone-calorimeter* method, according to ISO 5660-1.

Abroad (Fang *et al*. 2015) and in the country (Comșa 2011), the researchers' preoccupations have been lately directed towards the creation of layered products, in low-density species, with a view to replacing the high-density species, currently used in wood floors for heavy traffic. These prototypes have been achieved under the influence of temperature, steam and pressure, obtaining densified products, with improved mechanical strength, with attractive colour and relatively high dimensional stability, which are a solution for the future, as regards the heavy-traffic floors.

With a view to developing the raw-material basis (Comșa 2011), the enhancement of the less valuable and less used autochthonous species was promoted. In the same context, (Cismaru and Salcă 2009, Cismaru and Fotin 2014) submitted variants and solutions for fastening in constructions, the industrial wood floors in modular system, with a view to capitalizing the small-sized wood and to streamlining their assembly.

Owing to the fact that on the market there is a high diversity of unstandardized strips (Deteix *et al*. 2012) the researchers submitted a strip-shape design optimization strategy, by the introduction of a differing number of channels with different shapes on their back side. The submitted solution seems promising, in terms of strip-shape optimization, of transportation costs, by the diminished weight and increased stability, both during the processing and after the assembly.

In conclusion, we dare say a series of researchers have been preoccupied with the study of wood floors, for economic, aesthetic and resilience-related reasons. The optimization of the strip shape and of the parquetry structures leads to a complex database on wood floors. The promotion of the low-low-density autochthonous species as well as the capitalization of small-sized wood result in a more extensive raw-material basis.

GENERAL ELEMENTS

Wood floors have permanently evolved, over time, both in terms of general concept, and in terms of the wooden species, as well as in terms of the technical solutions for fastening in constructions. Moreover, important adaptations of the wood floors were achieved, with a view to equipping the constructions in different fields, which must fulfil additional functions, beside the constitution of a "structural carpet" with an aesthetic or thermal-insulation role.

Currently, the wood floors may be classified (Cismaru 2006) from several points of view; namely:

- In terms of *field of application*:
  - floors for civil engineering;
  - floors for industrial engineering;
  - floors for socio-cultural buildings;
  - agrozootechnical floors;
  - special floors.
- In terms of *structure*:
  - pavers or paving block-type flooring;
  - slab-type flooring;
  - floorboard-type flooring;
  - parquetry-type flooring;
  - plate-type flooring.
- In terms of *fastening solution in construction*:
  - floors fastened directly on the construction plates;
  - floors fastened on rigid elements (small beams);
  - floors fastened on elastic elements (elastic carpets, buffers, strips);
  - floors fastened on complex structures.

If we analyze the varied combinatorial possibilities to achieve the floors, solely from these three viewpoints, we dare say a multitude of structural variants can be conceived, manufactured and applied – yet

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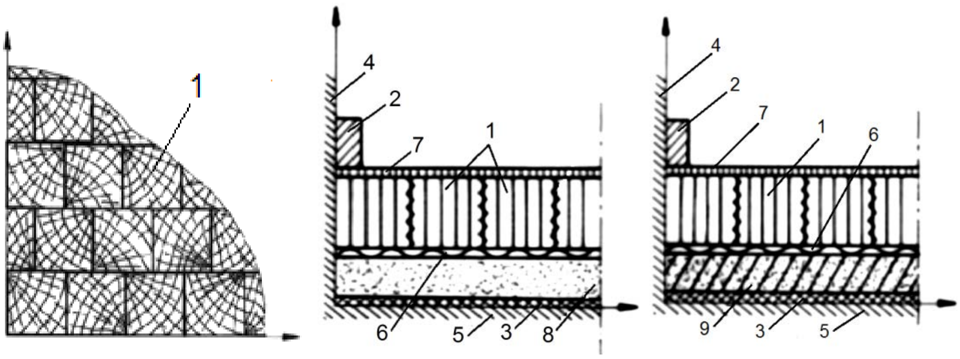
differentially, according to the type of construction (such as private house or block of flats); according to the level of the space on the vertical of the construction (ground or upper floors), according to the geographic area wherein the building is located (cold or warm areas) etc.

Due to their capacity to ensure great flexibility in conceiving the structures for the various situations to be solved, wood floors are an important design and utilisation variant for the civil engineers and architects.

FASTENING SOLUTIONS AND STRUCTURES IN CONSTRUCTIONS

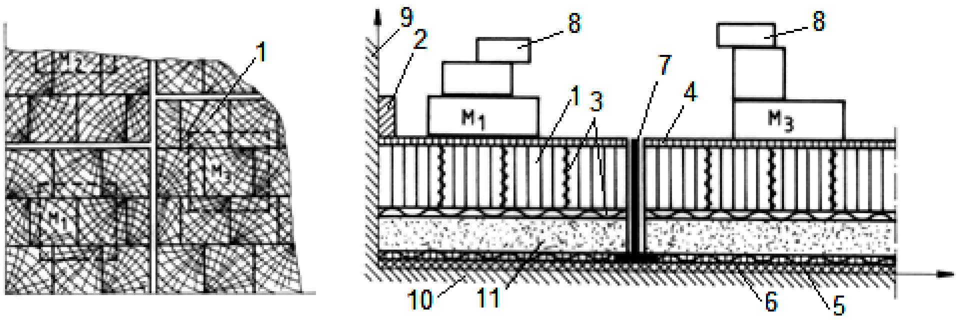
The structures of the wood floors are mostly defined by the functions they have to fulfil; and the fastening solutions, according to the type of building where they are fastened (Cismaru 2009).

In terms of industrial flooring, one has to consider that they must take great forces from the plants and from the equipment, either stationary or moving, which may generate shocks and vibrations to be buffered or not (depending on the field of activity they equip). These floors have solid structures, being made of blocks in solid wood (oak or acacia) attached to the construction, by bitumen (at ground floor and in the case of the foundations with high capillarity) (see fig.1 and fig.2). In the case of the spaces specific to the industries of textiles, electronics, pharmaceuticals, the flooring can be made of slabs attached by binders on the resistance elements of the buildings (see fig.3).



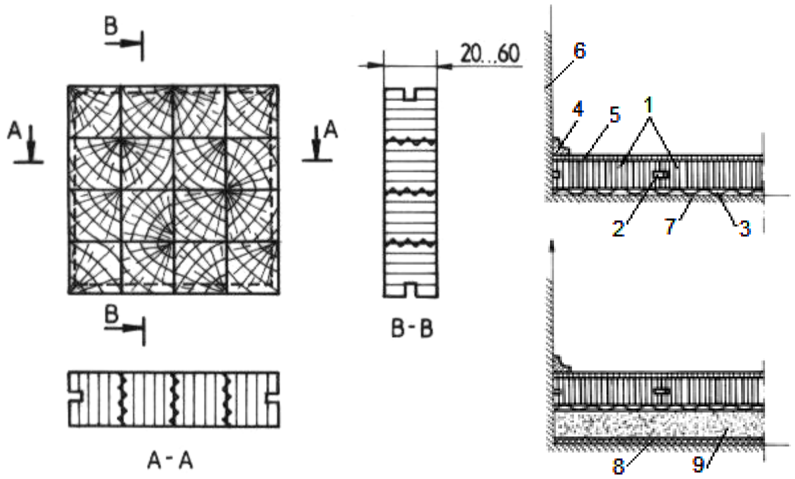
a b c

Fig. 1.
Industrial floors made of cubic blocks
a – constructive variant in blocks without technical core; b, c – flooring structures 1 – carpet of cubic blocks, in solid wood; 2 – wall plinth; 3 – vapour barrier layer; 4 – building wall; 5 – foundation in concrete or resistance floor; 6 – binder fastening the blocks in the carpet; 7 – wear layer (pellicle-forming or other materials); 8 – equalling screed; 9 – reinforced-concrete layer.



a b

Fig. 2.
Vibroinsulating industrial floors, made of solid wood blocks
a – constructive variant with cubic blocks; b – flooring structure
1 – carpet in blocks; 2 – wall plinth; 3 – binder layer; 4 – wear layer (pellicle-forming or other materials); 5 – vibroinsulating layer; 6 – vapour barrier layer; 7 – gliding and delimitation profile; 8 – processing machines; 9 – building wall; 10 – resistance plate (rarely foundation); 11 – floating equalling slab – reinforced concrete.



a b

Fig. 3.
Slab-type flooring
a – Form and structure of a slab in wood blocks b – Structures
1 – slab carpet in blocks; 2 – applied tether; 3 – binder layer; 4 – window sill lath 5 – pellicle wear layer; 6 – constructive wall; 7 – resistance floor; 8 – vapour barrier layer; 9 – equalling screed.

Agrozootechnical floors are mainly split into two great categories, namely: flooring for the animal-breeding spaces and flooring for warehouses and storerooms. The structures of these wood floors differ, so that the former should allow the rapid and easy cleaning of the respective spaces (see fig.4) and the latter should allow better insulation from damp, rodents or other pests (see fig.5).

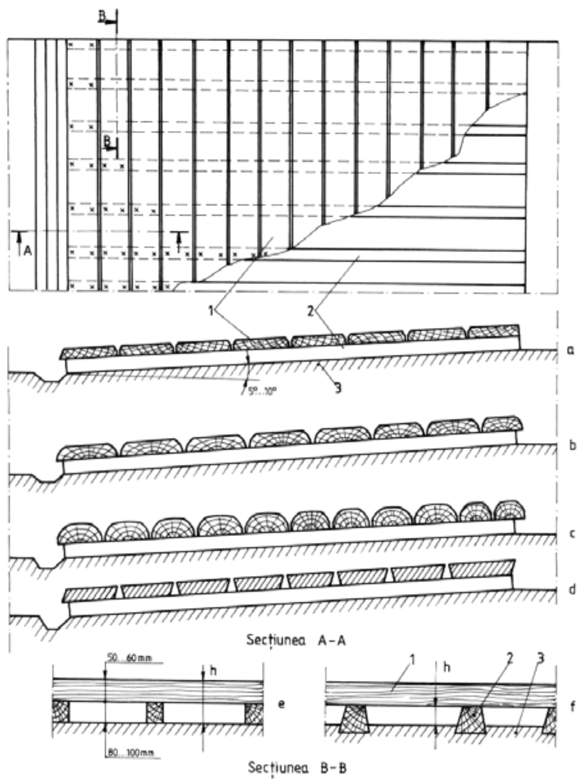


Fig. 4.
Structures and type of fastening for the transversal flooring, destined to the zootechnical sector
1 – carpet in solid-wood elements; 2 – beam-grid; 3 – building foundation.

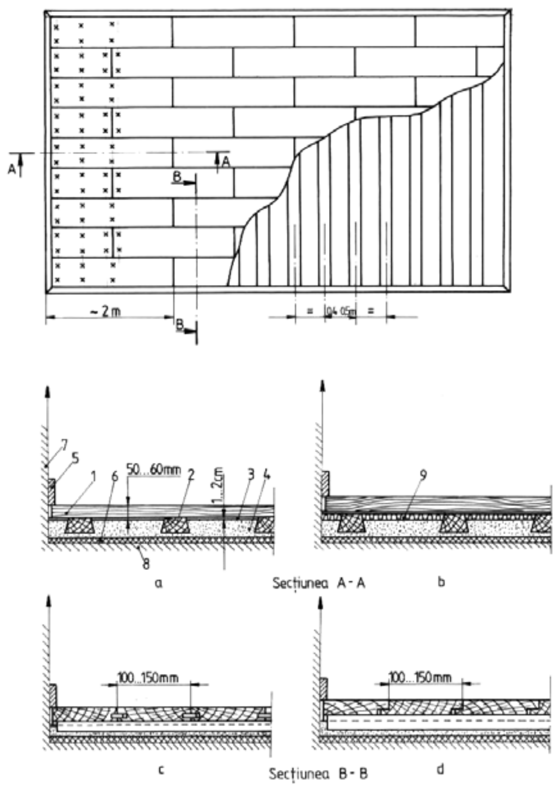


Fig. 5.
Structures and type of fastening of the flooring for warehouses
1 – rectangular-board carpet; 2 – small-beam network fastened in screed; 3 – air space; 4 – equalling screed.

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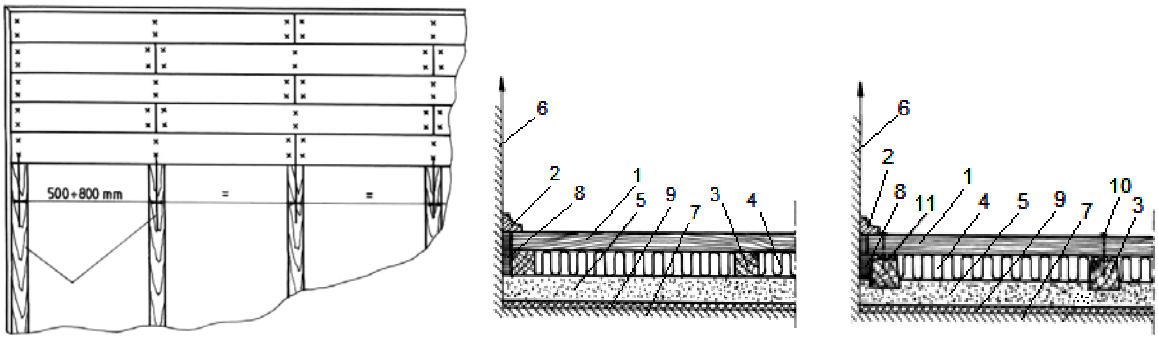
The flooring for socio-cultural constructions must ensure, first of all, long wear-resistance duration, with the possibility of rapid and easy maintenance (even by washing). These types of flooring are mainly fit for the wood of a high wear-resistance (oak or acacia), as well as for the special wood obtained by special thermal treatments (TERMOWOOD), by impregnation with chemicals (oils, primers, veneers) or by the application, in superficial layers, of plastics or polymerisation materials.

As regards the flooring for socio-cultural spaces, one must consider the sanitation of the wood; used either as boards, or as strips; in order to achieve a good durability, in time, at “humid traffic” or maintenance by washing.

A special category of the socio-cultural flooring consists in the floors of the gyms; dance, ballet, aerobic halls etc. One can say these floors are a special category, given the “behaviour” they must offer, according to the type of activity to deploy on these floors – a subject to be further developed within this work.

The flooring for civil-engineering mainly comprises three great categories, namely: classical flooring, board-type flooring and parquetry flooring.

Floorboards (rustic) are specific to private houses and they consist in a carpet of boards, in the lower part of the building spaces (fig.6). The carpet of boards may be constituted by direct joining, by tether and groove, by edgers or with applied tether (see fig.7).



a b c

Fig. 6.
Flooring in carpet of boards
a – modalities to arrange the small-beam grid; 1 – carpet of boards; 2 – wall lath (plinth, window sill); 3 – small beams; 4 – fastening nails; b, c –structures and fastening solutions in constructions; 1 – carpet of boards; 2 – wall (window sill) plinth; 3 – small-beam network; 4 – filling material (thermo insulating and soundproofing); 5 – equalling screed; 6 – building wall; 7 – foundation or resistance flooring; 8 – sound absorbing material; 9 – vapour barrier layer; 10 – fastening nails; 11 – vibroinsulating material.

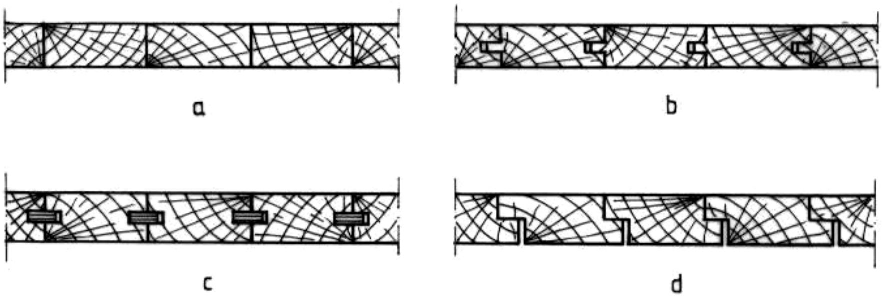


Fig. 7.
Methods to make the carpet of boards in classical floorboards
a – by joining on straight edges; b – by tether and groove; c – with applied tether; d – in edgers.

The fastening in construction is achieved with a small-beam grid applied on the foundation or on the resistance plates of the buildings; or with beams embedded in the resistance structure, which are prismatic wooden pieces, with the role to ease the fastening with nails or screws.

These wood floors may be structurally conceived, in the current situation, much more easily, with materials disposed as layers, in structures, with a view to achieving better insulation during the water circulation through the capillarity and/or to achieving a good heat and sound insulation (see fig.8).

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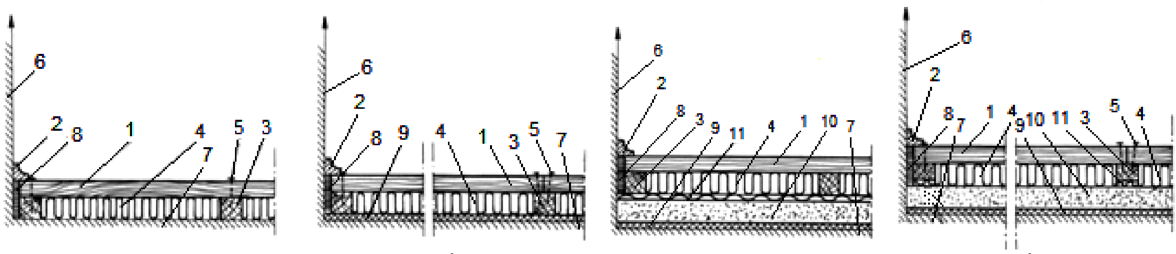
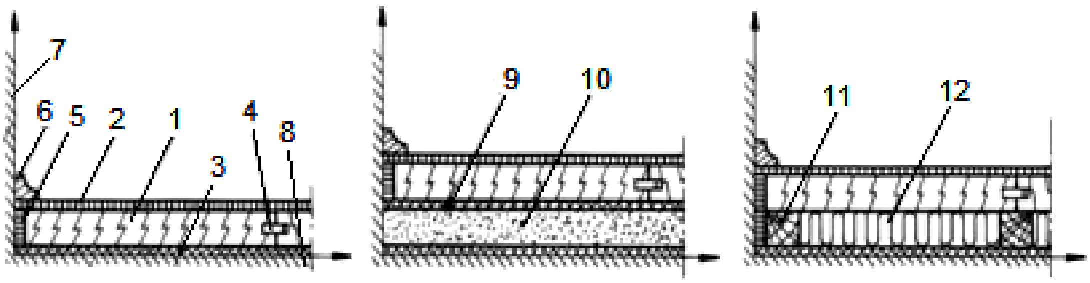


a b c d

Fig. 8.
Structures and fastening solutions, in constructions, of the flooring in carpet of boards
1 – carpet of boards; 2 – wall (window sill) plinth; 3 – small-beam grid; 4 – filling material (thermo insulating and sound proofing); 5 – fastening nails; 6 – building wall; 7 – foundation or resistance floor; 8 – sound absorbing material; 9 – vapour barrier layer; 10 – equalling screed; 11 – vibroinsulating material

Floorboards entered the urban environment, once with the development and the assimilation of the concept of “rustic”.

Board-type flooring appeared and developed, once with the achievement of materials meant to fulfil the role of the wear layer. These “endless-life” floors have the structure based, on one side, by the resistance similar to the classical flooring, where the role of the carpet of boards is taken by a carpet made of PAL, MDF or OSB boards, whereon the wear layer, represented by textile carpets or by P.V.C carpet is applied (see fig.9). Over time, the wear layer may be replaced and the resistance structure may resist.



a b c

Fig. 9.
Board-type flooring
1 – carpet of panels; 2 – wear layer; 3 – vapour barrier layer; 4 – applied tether; 5 – soundproofing material; 6 – lath-window sill; 7 – building wall; 8 – resistance floor; 9 – binder layer; 10 – equalling screed; 11 – small-beam grid; 12 – soundproofing and thermo-insulating filling material.

Board-type flooring is also being used for social spaces (schools, kindergartens, shops, company premises etc.).

Parquetry-type flooring, used to a maximal extent for the dwelling spaces, have started being used in the socio-cultural spaces (schools, conference halls, hotels etc.) as well as in gyms or for various “movement” activities. The parquetry made of “classical friezes” remains the most feasible and aesthetical; all the other variants (layered, laminated) trying to “aesthetically reproduce” the parquetry made of classical friezes.

The aesthetics of the surface parqueted with classical friezes differentiates according to the arrangement of the friezes in the carpet (fig.10).

The fastening in construction is differentially achieved, according to the fastening solution: frieze by frieze or as modules (Cismaru, Fotin 2014).

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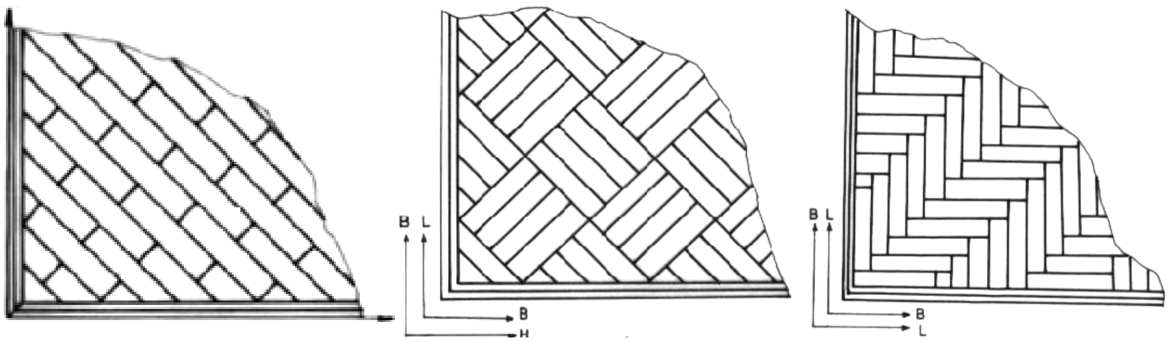
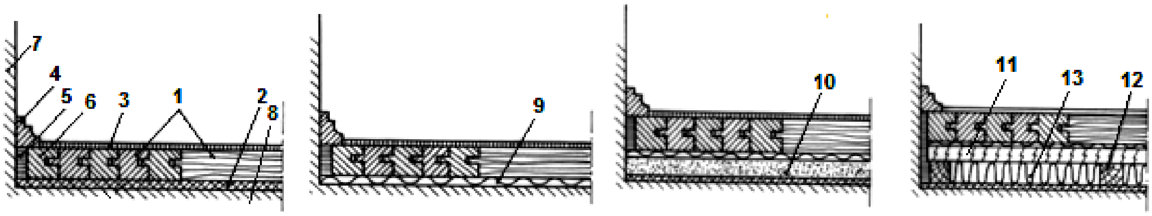


a b c

Fig.10.
Methods to arrange the parquetry
a - unidirectional – of the field friezes; b - checkered; c - in „W”.

The fastening in construction is differentially achieved, both on the surface of the construction elements and on the small-beam grid or on continuous surfaces, made of plates or of “blind flooring” (see fig.11).



a b c d

Fig. 11.
Fastening structures in construction of the carpet of parquet friezes
1 – carpet of field friezes (in any arrangement); 2 – vapour barrier layer (cast bitumen); 3 – protection and wear layer; 4 – window sill; 5 – soundproofing material; 6 – wall friezes; 7 – building wall; 8 – resistance flooring; 9 – binder layer; 10 – equalling screed; 11 – equalling panel; 12 – small-beam grid; 13 – filling material (soundproofing and thermo-insulating).

As regards the parquetry fastening structures, in construction, one must consider their thermal insulation capacity for the respective building.

SPECIAL STRUCTURES FOR THE PARQUETRY-TYPE FLOORS

Due to the day-to-day “computerized” activities, modern human being has passed to an ever more sedentary life; with great implications on his health; given that the human being is dynamic, not only intellectually, but also physically. Having become aware of this situation and given the excessive urbanisation of life, solutions have been thought, with a view to creating an environment where the human being might work out, either developmentally or competitively. Beside the “classical” sports activities, the human being invented other “sports activities” meant to work out his physical body and therefore ensure, according to his tastes and aptitudes, “the share of movement” necessary for a healthy existence. In the urban environment, these activities generally develop in especially arranged spaces and with specialized guiding. In this way, there emerged: ballroom dancing, aerobics, fitness, sports gymnastics, beside the traditional sports (handball, volleyball, basketball, badminton, football etc.).

The spaces where all these “movement activities” occur must be adequately arranged, in terms of flooring, in order to secure the sportsmen’s comfort” whereby the activities, the movements, the specific strains might be supported by the flooring, without affecting the human body.

In conceiving and manufacturing these types of floors, one must consider several factors, namely:

- specificity of the activity (with or without ball; with or without high jumps; with or without direct confrontation – body to body – of two or several participants etc.);
- sportsmen’s weight and level of the jumps – which define the forces that strain the flooring and the human body;
- force absorption and rejection capacity by the flooring, with a view to ensuring the participant’s protection and comfort – which may be attained by a certain degree of elasticity;
- optimal elasticity (minimal – maximal écart) which ensures the comfort in the deployment of the respective motion;

- absorption and rejection capacity of the contact with the ball – at the activities with the ball as game object;
- reliability of the flooring structures – with 10-year utilisation duration;
- possibility of rapid and easy maintenance;
- relatively acceptable cost, given the relatively high investment, for the gyms – a reason having many a time led to renouncing the wooden flooring or to adopting costless, yet “nonperforming” solutions.

Designing and manufacturing the wooden flooring for the spaces where people come to work out must likewise consider the “level” of these activities, to wit:

- in terms of “body-maintenance” gyms, specific to the socio-cultural spaces, where people with various weight, mobility, sports skills can participate, and which have to fulfil a wide range of “functional pretensions”;
- in terms of “physical-development” gyms, specific to the school sports facilities, one must consider their use by pupils or students, so that they might answer the specific conditions for a wide range of aspiring “sportsmen” – with an equally wide range of body weights;
- as regards the performance sportsmen’s training and competition gyms, which must ensure the “comfort” in playing several sports, over time, in the same sports facility; in this case, the flooring should not negatively influence the specific conditions to playing any sports discipline (scheduled to be carried out).

If we consider the concept of “polyvalent” gyms, wherein various sports activities should deploy, it goes without saying that designing and manufacturing the wooden flooring will take into account the most demanding sports discipline, in terms of the forces emerging and discharging through the flooring, as well as the specificity and the dimensions of the ball, which should jump up to a certain level, without demanding great efforts from the sportsmen.

Under these circumstances, one might say that basketball could be taken as a basis, in sizing and designing the structures of the wooden flooring.

Under the current circumstance, the “elastic structures” of the wooden flooring are achieved under the form shown in fig.12, as the most simple and costless variants; the elasticity being conveyed by the elasticity itself of the carpet of friezes.

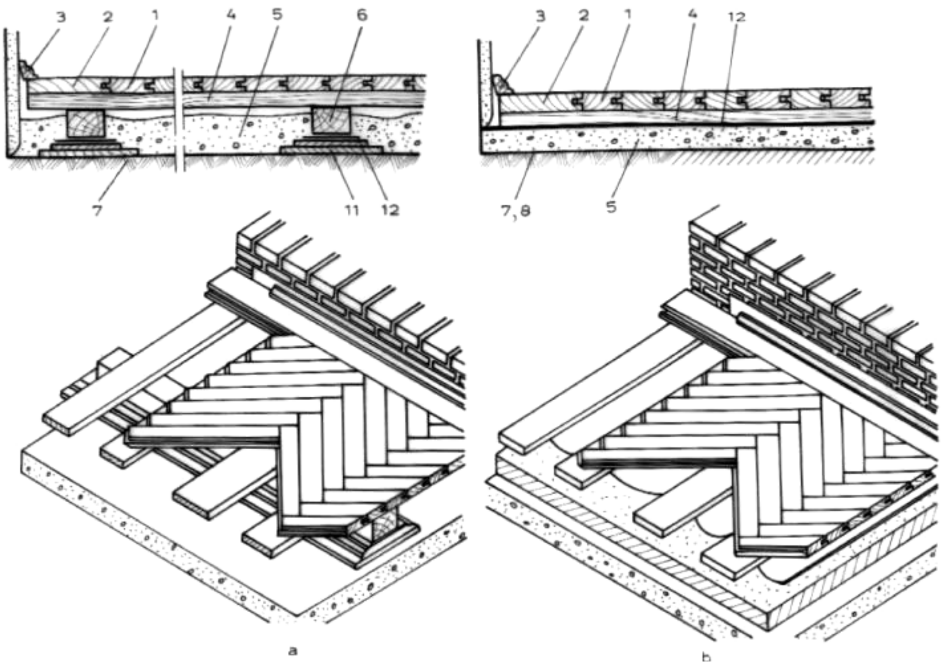


Fig.12.
Fastening modalities of the classical flooring
a – with waterproof insulation of the small beams and with thinned blind flooring; b – on reinforced-concrete floor, with blind flooring fastened in bitumen; 1 – carpet of field friezes; 2 – wall friezes; 3 – window sill; 4 – blind flooring (g=2cm); 5 – filling material; 6 – small beams (56x76 or 80x100); 7 – gravel; 8 – reinforced concrete floor; 9 – binder; 10 – bitumen; 11 – boards or small beams; 12 – bituminous cardboard.

The variant shown in fig.13 considers the use of several simple structures, with additional rigid clogs, with fixed positions, which allow greater mobility and elasticity of the carpet of friezes.

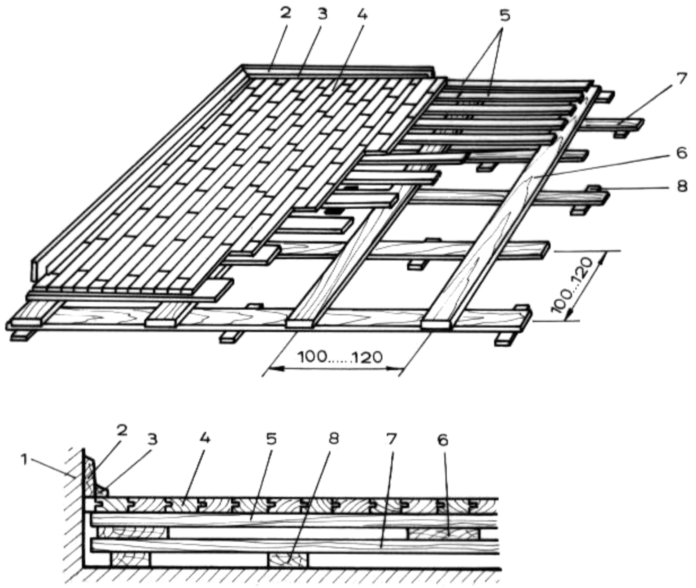


Fig. 13.
Structure of the elastic flooring, specific to the sports facilities
1 – building wall; 2 – wall plinth; 3 – window sill; 4 – field friezes; 5 – grid of elements in solid wood (blind flooring); 6 – elastic boards (I); 7 – elastic boards (II); 8 – support legs.

Starting from the condition of “flooring elasticity”, which must be functionally achieved, some structures can be designed so that they might incorporate elastic layers or materials, which should contribute, in their turn, by their own elasticity, to the “overall elasticity”. In this way, the goal of optimal operationally will be attained.

The arrangement of the wooden friezes, with a view to supporting the field (continuous boards of the flooring) can be achieved in different variants, resorting to friezes of different sizes, which must rest, at their two ends or, even more efficiently, in three points (on two or three small beams) as shown in fig.14.

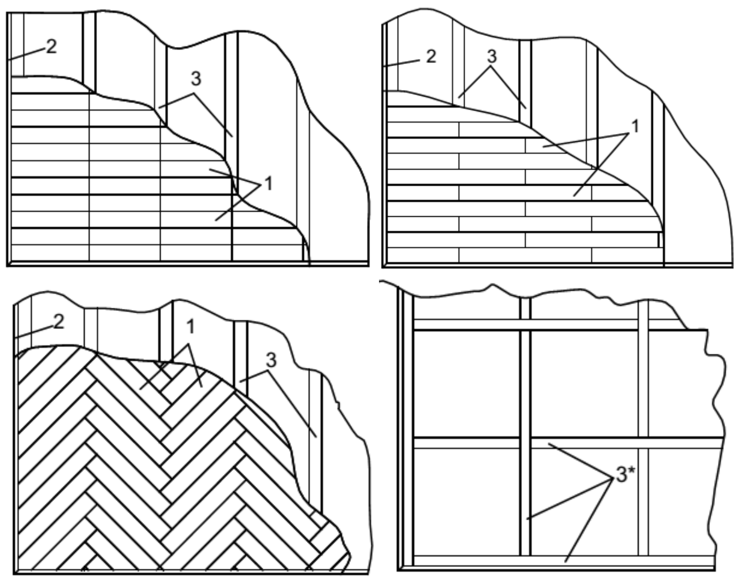


Fig. 14.
Variants to make up the field of friezes
1 – field friezes; 2 – window sill; 3 – small-beam grid (3*- checkered).

The elastic layer can take the form of a carpet, strips or elastic buffers, set in the structure, as shown in fig.15.

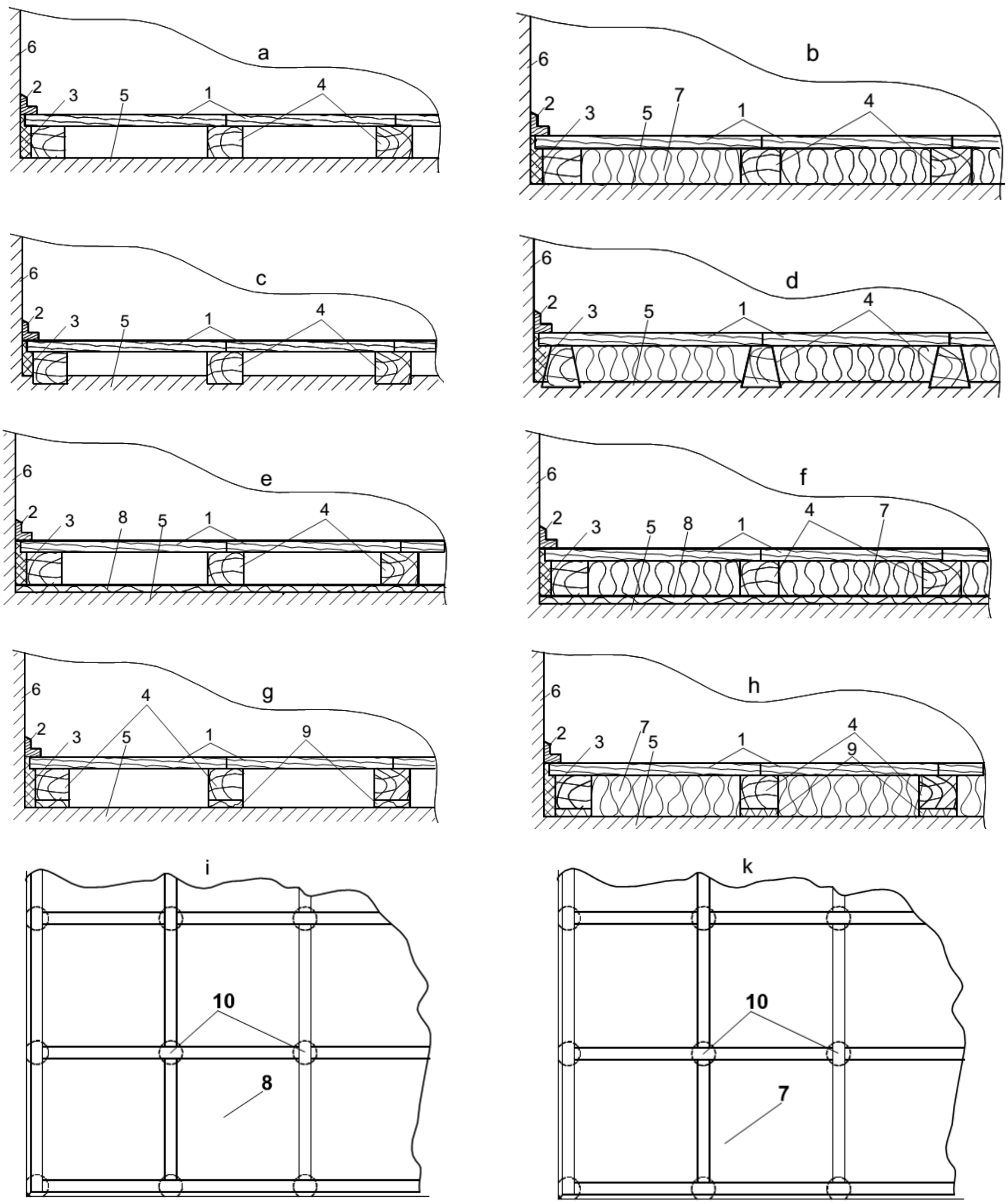


Fig. 15.
Possible structures for the wooden flooring, to be used in the sports facilities – fastening in construction; 1 – field friezes; 2 – window sill; 3 – soundproofing material; 4 – small-beam grid; 5 – resistance floor;6 – wall; 7 – elastic filling; 8 – elastic carpet; 9 – elastic strips; 10 – elastic buffers.

Obviously, various elastic structures can be conceived, which should result in the optimal elasticity of the wooden flooring. Nevertheless, these submitted structures must go through the stages of testing, assessment, practical analysis etc., with a view to defining the optimal variant.

CONCLUSIONS

Wooden flooring cannot disappear from the structure of the buildings, given the great diversity of their applicability.

Through an attentive and thorough analysis, we have come to the conclusion that wood floors must modify their structural designs, due to the apparition and possibility to use other types of materials, which bring an important contribution to the improvement of all functions (elasticity, thermal transfer capacity, soundproofing capacity, aesthetic capacity etc.), according to the field of application.

Here we come to the point where wooden flooring (especially the parquetry-type flooring) must be structurally designed and sized according to the prevailing activity, to be developed in the respective spaces.

If we consider the ongoing development and diversification of the “sports of high mobility”, either non-competitive or competitive, a problem sets its mark as pending necessity – that is, designing and manufacturing the wood floors for the halls dedicated to “movement activities” and sports activities, either developmental or competitive, in such a structural diversity, so that optimal conditions might be provided.

Under these circumstances, the research activity in the field of wooden flooring for “movement activities” is a must. In its framework, both the functional diversity and the costs and reliability of these structures should be taken into account.

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